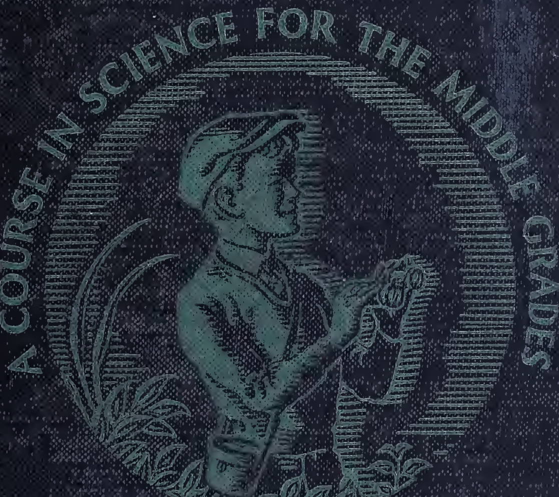
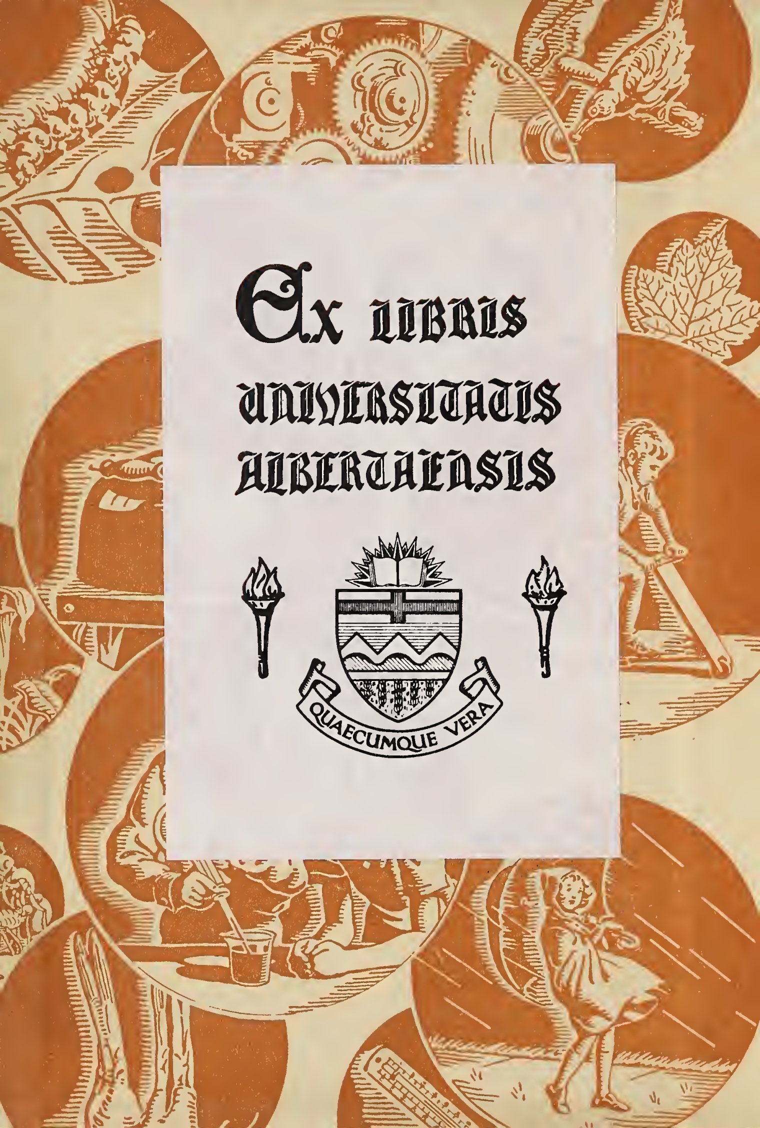
DISCOVERING OUR WORLD



A COURSE IN SCIENCE FOR THE MIDDLE GRADES

BOOK TWO



Ex libris
universitatis
albertaensis

QUAECUMQUE VERA

PROVINCIAL ARCHIVES
OF ALBERTA
ACC. 73.110

Digitized by the Internet Archive
in 2016 with funding from
University of Alberta Libraries

https://archive.org/details/curriculumfounda02beau_1

Basic Studies in Science

DISCOVERING OUR WORLD

A Course in Science for the Middle Grades

by

WILBUR L. BEAUCHAMP
GLENN O. BLOUGH MARY MELROSE

• BOOK TWO •

SCHOOL DIVISION
PUBLIC LIBRARY
WETASKIWIN - ALBERTA.

Toronto
W. J. Gage & Co., Limited

ACKNOWLEDGMENTS

For valuable critical help on Discovering Our World, Book Two, the authors make grateful acknowledgment to the many supervisors and teachers who in personal conference and through critical reading of the manuscript did much to check and guide the authors' thinking. Among those who rendered help, especial thanks are due Miss Irene Sauble, Assistant Supervisor, Department of Exact Sciences, Detroit, Michigan; Miss Anna E. Burgess, Principal, Doan School, Cleveland, Ohio; Mr. Joe Young West, Maryland State Teachers College, Towson; Miss Lillian Hethershaw, Head of General Science Department, Drake University, Des Moines, Iowa; Mr. Wilber Emmert, Teacher of Science and Director of Visual Education, State Teachers College, Indiana, Pennsylvania.

Acknowledgment is made to the following for permission to publish the photographs on indicated pages: Bausch & Lomb, page 273; Black Box Studios, 166; L. W. Brownell, 27, 47, 56, 236, 239, 274, 285, 288, 295, 296, 304, 306, 307, 310, 315, 318, 325, 327; Century Photos, Inc., 30, 93, 156, 171, 226, 294, 304, 326; Century-Allen, 17, 76, 88, 93, 156, 232, 260, 269; Century-Chace, 236, 288, 310, 326; Chicago Academy of Sciences, 44, 293, 309, 327; Chicago Aerial Survey, 171, 175, 193; Chicago Daily News, 291; Corning Glass Works, 222; Diamond Chain Co., 94; Diemer Photos, 268; Field Museum, 12, 14, 24, 31, 235, 264, 293; Haynes, Inc., 27; Ferdinand S. Hirsh, 19, 44, 56, 59, 70, 78, 80, 82, 88, 90, 91, 98, 99, 134, 141, 152, 154, 164, 210, 260, 294; Paul G. Howes, 21, 22, 46, 49; Kaufmann & Fabry Co., 94, 95; J. Horace McFarland Co., 36, 37, 285; James Plagge, 237; H. Armstrong Roberts, 106, 107, 125, 127, 134, 141, 154, 171, 172, 173, 177, 178, 179, 180, 182, 184, 187, 191, 239, 305, 313; Santa Fe Railway, 300; Orville Logan Snider, 137; Hugh Spencer, 27, 34, 36, 41, 42, 45, 236, 238, 239, 241, 243, 247, 256, 258, 290, 310, 315, 317, 322, 323, 326, 327; Underwood & Underwood, 52, 190; United States Department of Agriculture, 38, 40, 41, 44, 48, 49, 50, 53, 56, 61, 62, 165, 249; Wendell MacRae and the Round Table Press, 6 (from *Willingly to School*).

All rights reserved

Printed in the United States of America

LIBRARY
UNIVERSITY OF ALBERTA

CONTENTS

WHAT DOES DISCOVERING OUR WORLD MEAN? 7

UNIT 1. HOW DO LIVING THINGS HELP AND HARM EACH OTHER? 13
How do animals help each other? 16
How do plants help animals? 26
How do animals help plants? 29
How do plants help other plants? 35
How do plants harm other living things? 39
How do animals harm other living things? 44
How do plants help us? 51
How do animals help us? 55
How do we help the living things that help us? 59

UNIT 2. HOW DO MACHINES HELP US DO OUR WORK? 69
What is a machine? 69
How do pulleys help us do work? 72
How do levers help us do work? 81
How do inclined planes help us? 87
How does the wheel and axle help us? 91
How can we make machines work better? 96

2751347

UNIT 3. HOW DOES HEAT CHANGE MATERIALS? 103
- How does heat change the size of solid materials? .. 103
- What happens to liquids when they are heated? 108
- How does heat change gases? 114
- How much heat does it take to change solids to liquids? 122
- How much heat does it take to change liquids to gases? 125

UNIT 4. WHY DOES THE WEATHER CHANGE? 133
- What is weather? 134
- Why does the temperature change? 138
- What makes the wind blow? 142
- How do we measure air-pressure? 148
- What makes it rain and snow? 152
- How does the "weather man" find out what the weather will be? 158
- How are the weather forecasts used? 163

UNIT 5. HOW DOES THE SURFACE OF THE EARTH CHANGE? 169
- What does the earth's surface look like? 170
- How does water change the surface of the earth? ... 174
- How does air change the surface of the earth? 182
- How do plants change the surface of the earth? 185
- How have glaciers changed the surface of the earth? . 186
- How do volcanoes build up the earth's surface? 189
- How are mountain ranges made? 192
- What is soil? 193

UNIT 6. WHAT ARE THINGS MADE OF? 199
- How are materials different from each other? 201
- How can we change the characteristics of materials? . 206
- What are elements? 211
- How are elements joined together? 214
- How do we use chemical changes? 221
- How can we stop harmful chemical changes? 225

UNIT 7. HOW DO LIVING THINGS GET FOOD? 233
How do animals get food? 234
How do green plants get food materials? 241
How do water and air get to the leaves? 245
How does a leaf make food? 248
What becomes of the food made by the leaf? 255
How do plants that are not green get food? 257
How do we get food? 260

UNIT 8. HOW DO PLANTS AND ANIMALS MAKE OTHERS LIKE THEMSELVES? 265
Why are flowers important? 267
How does a pollen grain help to make a seed? 272
How do plants without flowers grow new plants? . . . 276
What other parts of plants will grow into new plants? 281
How do animals make more of their own kind? 287
How do living things take care of their young? 293

UNIT 9. HOW ARE LIVING THINGS FITTED TO LIVE IN DIFFERENT PLACES? 301
How are living things fitted to live on land? 305
How are living things fitted to live in the water? . . . 315
How do living things change as the seasons change? . 319
How are living things protected from their enemies? . 325
How are people able to live in almost every place on the earth? 329

SCIENCE WORDS 334

INDEX 341

What Does Discovering Our World Mean?

FOR HUNDREDS of years explorers have been discovering new places in the world. Columbus discovered a new land, and Admiral Byrd discovered new regions near the South Pole. But nearly all of the lands in our world have now been discovered and explored.

Traveling to far-away places is not the only way of discovering our world. We also discover our world when we learn what kind of world it is. All around you there are thousands of things that you have never seen or heard about. They are just as interesting and just as exciting as anything that the great explorers ever found.

In this picture a boy and a girl are discovering interesting things about the world they live in. You are very much like this boy and girl. You have eyes and ears, and you can think and plan. You can see and hear many of the things that go on around you, and you can find out how they happen.

Here are some of the things that happen near you every day. Can you explain how they happen?

The wind blows.

Plants change water into something else.

Animals help plants.

Plants help animals.

The sunshine makes the water disappear.

Bees help flowers to make seeds.

The plants make food.

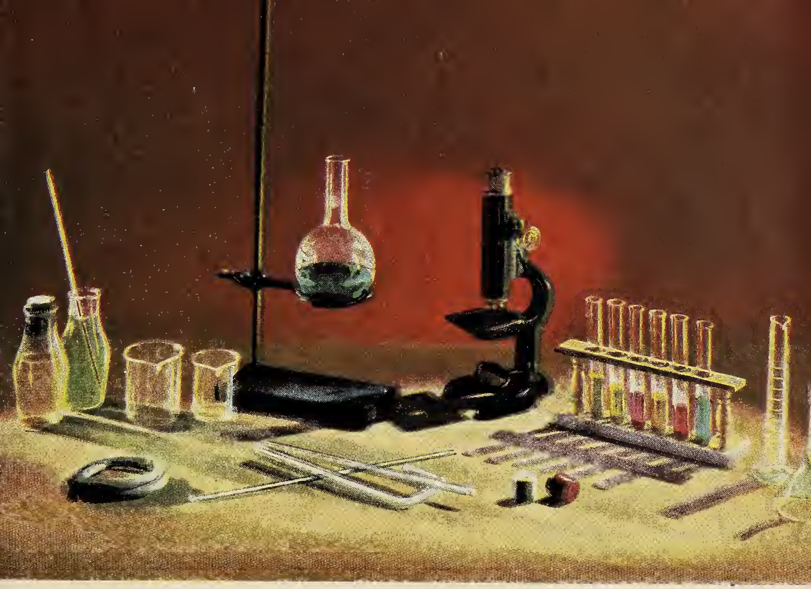
The weather changes from sunshine to rain.

The seasons change and so do the plants and animals.

Probably you do not know how these things happen. Do you know how to find out?

One way to find the answer to such problems is to *look carefully* at the things around you. To do this you need to think about what you are seeing. You need to take plenty of time so that you will discover as much as you can.

Another way of finding out about the things around you is to *read* books. There are certain things to remember when you read books to find information. Some books are written to be read for fun. They do not always give you correct information. Be sure that the books you read for information were written by authors who write true



Probably you will use these things when you experiment. Find the rubber tubing, the glass tubing, the rubber stoppers, and the microscope. Two beakers are standing near a ringstand that is holding a flask. There are six test tubes standing in a rack.

books. Often it may be necessary for you to read several books to see if they agree before you decide if the books are correct.

The books you read in science should not be too old. The science information in old books may have been thought correct when the books were written, but scientists make new discoveries every year, and new books are likely to be more nearly correct.

One of the most interesting ways of discovering new things is to do experiments. When you experiment, you try out different things to see how they work. You will wish to do many experiments as you learn about the things around you.

There are certain things to be careful about when you experiment. You should always work carefully and be sure to follow the directions that are given in your book. Watch carefully to see what happens. Think carefully to see why it happens. Try your experiment more than once so that you can be sure that it is done correctly.

Many of the discoveries in the world have been made by scientists. Scientists are men and women who study the things on the earth and inside the earth. They are really discovering our world because they are always finding out new things about it.

Scientists discover new things by experimenting and by looking carefully at things about them. They often work in their science laboratories, but they also make discoveries everywhere about them.

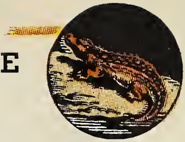
Not all of your science discoveries will be made in your schoolroom. Many of them will be made at home, on the playground, and everywhere around you.

If you wish to find out what discoveries this science book will show you, look at the Table of Contents on page 3. It will tell you some of the science problems that you are going to learn how to answer.

Perhaps there are some other questions that you would like to ask. If there are, you may make a list of them and see how many of them you can answer as you study your book.

As you study this book, you will find some new words that scientists use. You will want to know what they mean, so that you can use them, too. In the back of your book is a list of these words. The list tells you how to pronounce them. It also tells you what the words mean. Turn to page 334 and examine the list, so that you can see how it will help you.

UNIT ONE



HOW DO LIVING THINGS HELP AND HARM EACH OTHER?

DO YOU KNOW how fish help you to have buttons on your clothes? Perhaps you know that many of these buttons are made from clam-shells. Once upon a time, not many years ago, the men who make these little white buttons became worried. They could not find enough clams in the rivers. They asked scientists to find why the clams were disappearing, and this is what the scientists discovered.

When clams are first hatched from eggs, they are tiny little things, not much bigger than a pinhead. They float around in the water until they fasten themselves to the gills of fish. Here they stay until they are big enough to live without the help of the fish. The reason that the clams were disappearing from the river was that fishermen had caught most of the fish. Therefore the baby clams could not stay alive. Without the fish there could be no clams, and without the clams there could be no buttons from clam-shells.

This little story tells you of just one of the many strange ways in which living things need each other.

If many deer were to eat the twigs and gnaw the bark of these trees, what would happen to the trees?

Here is another story that shows you how living things get along together.

Would you have any idea that mountain-lions and wolves could save forests? High up in the mountains in the western part of our country is a beautiful national forest. A few years ago scientists found that many of the trees and other plants in this forest were dying. They were dying because the deer in the forest were killing them. This may seem strange to you because you know that deer have lived in forests for hundreds of years and have not killed the trees. But this is what was happening: In this forest were wolves and mountain-lions that killed the deer for food. The men who had charge of the forest decided to kill the mountain-lions and wolves so that the deer would be safe. When this was done, the herds of deer became larger and larger because almost every deer that was born grew up to full size. Soon the herds were so large that there was not enough food for them. They became so hungry that they began to gnaw the bark on the trees. Of course this killed the trees. To save the trees men had to kill some of the deer. Do you see now how the wolves and the mountain-lions helped save the forests?

This story of the deer is another example of the strange ways in which plants and animals need each other and use each other. You know that every living thing must have air to breathe and water to drink. But living things need other living things almost as much as they need air and water. You, too, are a living thing, and every day of your life your plant and animal neighbors help you in some ways and harm you in other ways.

You can easily see that men and women and boys and girls find many, many uses for plants and animals. But perhaps it is not so easy for you to see how animals need each other, how plants need each other, and how plants and animals need each other. This book will tell you many of the ways in which living things help and harm each other.

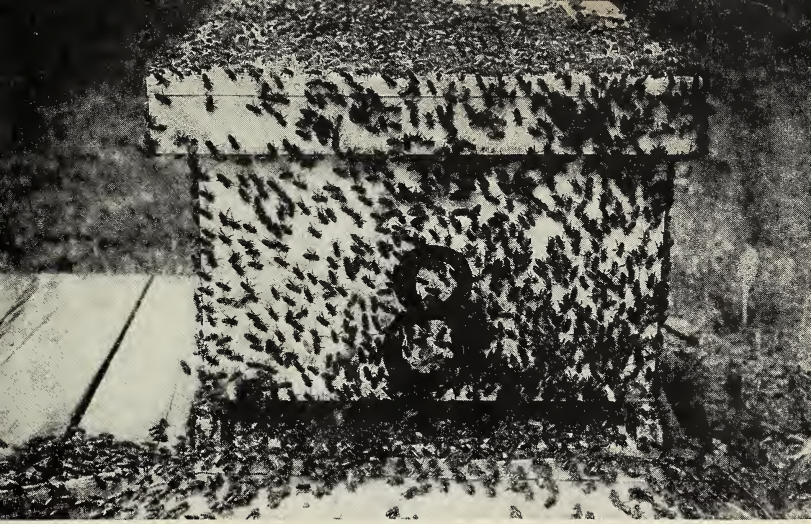
But you can find interesting things yourself if you watch your living neighbors closely every time you are out-of-doors.

Before you read these pages about plants and animals, you must be sure to understand one thing. You must not get the idea that plants and animals *know* that they are helping or harming each other. Plants and animals need food, shelter, air, water, and light. As they try to get these things, they sometimes help and sometimes harm other living things. This helping and harming just happens to take place. The living things do not plan to help or harm each other.

How do animals help each other?

SUPPOSE you take a trip out across the fields and through the woods or out to some park in your town. Watch every animal that you see and try to find out what the animal is doing. Study the plants that you find. As you watch these living things, try to find answers to this question: How do plants and animals help and harm each other?

The science class of the Elm Place School went on two or three trips to parks and vacant lots to watch plants and animals. The boys and girls also kept watching after school and on week-ends when they were out-of-doors. They decided to learn all they could about how animals need other animals.



This colony of bees has just left its old home and is moving into a new one.

Henry said that he thought he knew one way animals help each other.

"My father keeps honey-bees," he said. "And I know that bees have to live together in hives."

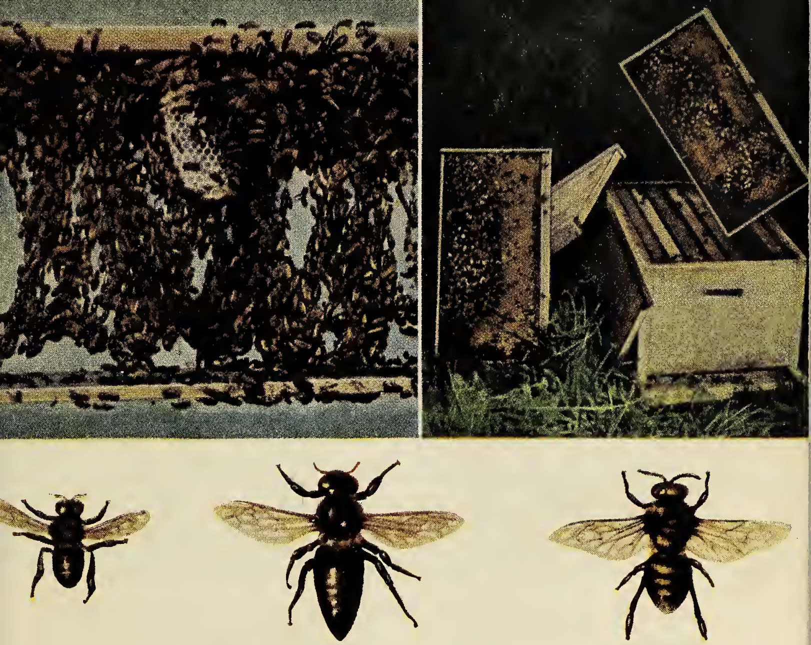
Miss Ball then told the class that honey-bees are very interesting animals to study. "They are called *social* animals," she said, "because they live and work together. They have to live together in *colonies* to stay alive. Sometimes there are as many as sixty thousand bees in a *colony*."

Then the class appointed a committee to study bees and other social animals. Some of the things they learned are told in the next few pages.

Almost all of the bees in the hive are called *worker* bees. They do all the work of the hive. The other bees are called *drones*. There are not many drones in a hive. They do no work, but the bee family could not get along without the drones. A drone is the father of the family. All of the bees are either workers or drones, except one bee. This bee is the largest in the family, and she is the mother. She is called the *queen bee*.

A beehive is almost like a little city, with every bee doing its work to keep the bee city going. Some bees fly over the fields and meadows, gathering materials for food. They find these materials in the flowers of plants. One of the materials is a sweet juice called *nectar*. The bees use the nectar to make honey. This honey is food for the bees. While the bees are getting nectar, they also gather *pollen* from the flower. Perhaps you have seen pollen in flowers. It looks like yellow dust. Bees use the pollen to make food.

Some of the worker bees are wax-makers. These bees eat their fill of food and then hang themselves from the top of the hive in long strings. In a short time wax begins to ooze from the under side of the bodies of the bees. Other worker bees take this wax and use it to make honeycombs. In these wax combs the bees store their honey and their bee-bread. They also put their eggs in these combs.



Here are some wax-makers hanging in strings and comb-builders making the wax honeycomb. At the right the bees are filling combs with honey. The three bees at the bottom are (left) worker bee, (middle) queen bee, and (right) drone.

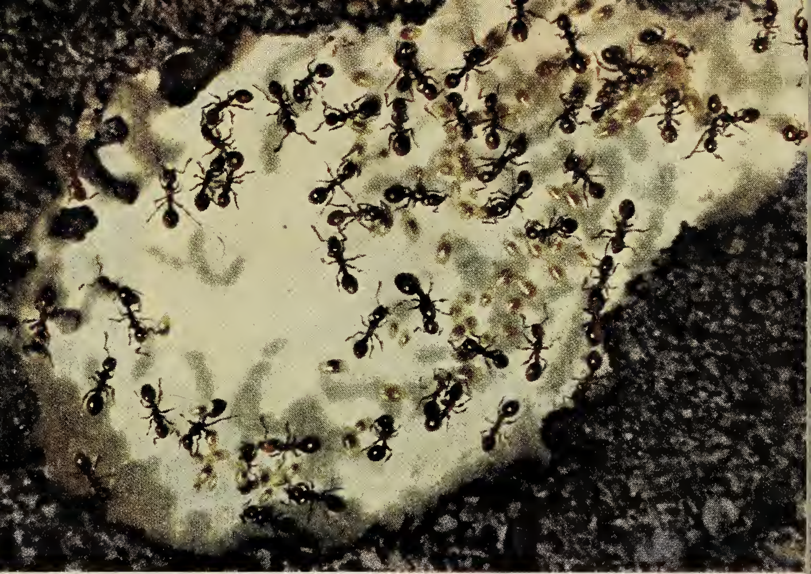
Some of the bees are housekeepers. They pick up the pieces of wax that fall to the bottom of the hive and carry them outside. When bees die in the hive, these housekeeping bees carry the dead ones out. Of course, there is always danger that some enemy may enter the hive. It is the duty of the guard bees to make sure that no "strangers" enter. If a wasp or some other strange insect or a bee from another colony tries to come into the hive, the guard bees fight it and sting it to death. Then they carry it out of the hive.

These hundreds of working bees must be supplied with fresh air while they are working in the hive. Some of the bees fan their wings swiftly back and forth to move the air and to bring in fresh air.

But all of this work would be useless if it were not for the queen. The queen bee lays all the eggs. Without her there would be no new bees to take the places of those that die. The hive would soon be empty, because the worker bees live only about six weeks.

Does the way the bees divide up their work remind you of your own city? In your city or village there are the street-cleaners, policemen, carpenters, storekeepers, and many other kinds of people. They work together so that everyone can have the things that he needs. No one person can do everything.

But there is one very important difference between the bee community and your community. Do you know what this difference is? Men and women plan the work in your community. They know why they help each other, and know that they are helping each other. Bees cannot think; so of course they cannot plan. They live together and help each other without knowing why they do so. They do not even know that they are helping each other.



Here is part of an ants' nursery. The small, light-colored objects are the young ants.

Ants also are social insects. It will be easy for you to have a colony of live ants in your classroom. You can dig up an ants' nest and put it in a glass jar with a fine screen over the top. Then tie paper around the jar so that the light will be shut out for awhile, and perhaps the ants will make tunnels in the soil near the glass.

Most of the brown or black ants live in nests built in sand or loose earth. Here they dig long tunnels and scoop out many rooms. Some of these rooms are nurseries where the young ants are cared for.

There are also storerooms for food. And would you believe it, some rooms are used for sleeping! Yes, ants sleep. When an ant returns to the nest carrying a supply of food, other ants rush out to meet it. They brush the dust off the ant, and then it goes to one of these sleeping-rooms, where it is soon fast asleep.

There are three kinds of ants in an ant colony, just as there are three kinds of bees in a colony. In an ant nest, though, there are usually several queens. In a very large colony of ants there may be fifty queens. The queen ants lay the eggs, too. In every nest there are hundreds of worker ants. Some go to get food; some look after the queens and feed them. Other workers take care of the eggs; others act as soldiers to guard the colony.

Scientists who have studied ants have found a very strange way in which animals help each other. Would you believe that ants keep "cows"? The ant-cows are really plant-lice, called *aphids*. The picture on this page shows two ants with their cows. These plant-lice suck the juice, or sap, from plants. They use some of this juice for food. But the ant "milks" the ant-cow to get some of the juice for himself. He does this by stroking the ant-cow with his feelers. When the ant-cow is stroked, it gives off a drop of the juice, and then the ant drinks the "milk."

But this is only half of the story. The ants take good care of their flock of ant-cows! They keep other insects from eating the aphids, and they take care of the aphids' eggs. Through the cold winter the ants keep the eggs and the cows down in the ground where the eggs will not freeze. When the warm spring days come and the leaves have grown on the plants, the ants bring the newly-hatched plant-lice out into the sun and put them on the leaves. There the plant-lice have plenty of food all around them. The ants have really taken their cows out to pasture!

Every day the boys and girls of the science class were finding ways in which animals help each other. Many of them told of watching a mother and father robin feed their nest of young. The parent robins make hundreds of trips every day to bring food to the hungry young robins. Even after the young birds have begun to learn to fly, the mother and father bring them worms and insects. The bird family lives together only as long as the young birds need to be taken care of; then the family life is over.

These musk oxen live in the far north. They stay together in herds. When they are attacked, they form a circle to fight their enemy.

Many other animals live together while the young need the mother's care. After that they, too, leave home. When young rabbits are born, they are as helpless as little kittens. For many days after young rabbits are born, they snuggle close to their mother and drink milk from her. The mother keeps them warm and safe.

Some kinds of animals join together so that they can capture food more easily. A group of wolves is usually called a *pack*. When a pack of wolves finds a deer or an elk in the woods, the wolves attack the animal and eat it. One wolf could not capture the larger animal, but many wolves together can easily kill their prey. Did you ever see a flock of little birds chasing a big crow that had been trying to rob their nests of eggs? Birds and some other kinds of animals often join together to fight an enemy.

Some kinds of animals warn each other of danger. Beavers do this by striking their flat tails on the water. This makes a loud noise. It is the signal for other beavers to dive under water and swim to their homes. Crows give warning cries, and the flock flies to shelter and safety. Many other kinds of animals give warning signals.

Animals need and use other animals in many, many ways. It would take you more than a lifetime to find out all there is to know about these things. If you have been watching your animal neighbors and reading other books, you have probably discovered many things that are not told in this book.

* * *

1. Explain why it is not possible for a bee to live without the other members of its family.

2. Why is the work of the queen bee so important?

3. Name some animals that live or hunt in groups and are able to:

a) get food more easily.
b) take care of their young.
c) warn each other of danger.
d) do work for each other.

4. Why is it often very necessary for animals to live in groups?

5. Name some animals that need other animals for food.

How do plants help animals?

When the boys and girls of the science class had learned how animals help each other in many ways, they decided to find out how plants help animals. One Saturday Bill and John took a hike through the woods and across the fields. They had not gone far before they saw a squirrel scampering along the ground. Soon they saw that he was helping himself to nuts that lay on the ground under some hickory trees. Quietly the boys watched. They saw the squirrel carry the nuts away to a hole high up in a tree.

"Here is a nut that some squirrel has been eating. Let's take it to school for our collection."

"The squirrel is using the tree for a home, too," added Bill.

As Bill and John walked along, they saw other animals using plants for food. In the fields close to the woods were cows, horses, and sheep eating grass. In the trees were birds eating fruits, and other birds were picking up plant seeds wherever they could find them.

"Some animals certainly could not get along without plants," said John. "Plants are the things they use for food."

But John did not stop to think that every animal needs plants. Horses, cows, sheep, deer, and elephants never eat meat. Tigers, lions, and foxes eat twigs, leaves, and the bark of plants. The boys found an old bird's nest made of twigs, grass, and mud. They took it for the school collection.

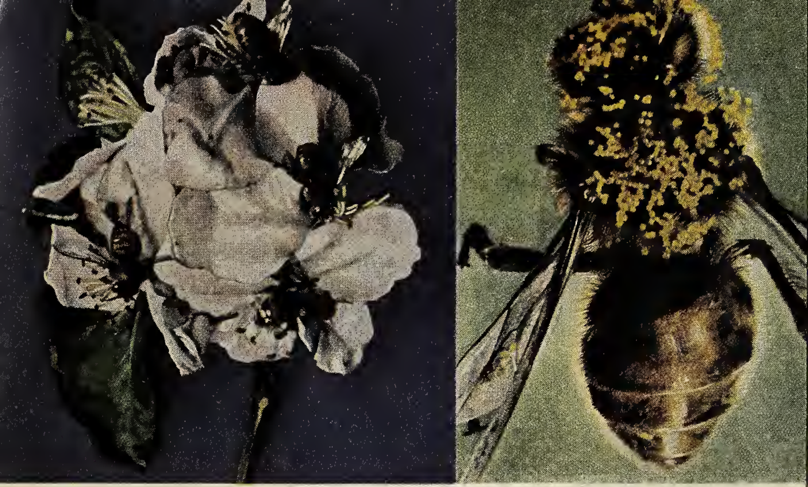
There were many other animals in the woods, but the boys did not discover them. These animals were small, and the boys never thought to look for them in their hiding-places. If they had looked under the leaves of plants, they would have found many kinds of worms and insects. Many kinds of small animals live under the leaves of plants that grow close to the ground. Crickets, grasshoppers, ants, small moths, cutworms, spiders, and snails live in the shelter of these leaves.

* * *

1. Tell three ways in which plants help animals.
2. Name five different animals that you have seen using plants. Tell how the plants helped the animals.

How do animals help plants?

IT HAD been rather easy for the boys and girls to find how plants help animals. But at first they could not see how animals helped plants very much. It seemed that animals were always destroying plants by eating them. But, like good scientists, they started out to see what they could discover. They went to work reading, asking questions, and observing plants and animals.



At the left are bees crawling over a flower in search of nectar and pollen. The bee at the right has part of its body almost covered with grains of pollen.

One of the most interesting things the boys and girls learned was how bees help flowers. You have probably many times seen bees crawling around over blossoms. You know that they are gathering nectar and pollen. Pollen is very important to flowers. Plants cannot grow seeds unless pollen gets down into the part of the flower where the seeds grow. Seeds make better and stronger plants if pollen from one plant gets into the flowers of another plant.

Bees are the carriers of pollen. When a bee climbs into a flower, some of the dusty pollen sticks to his hairy legs. When the bee crawls around on another flower, some of this pollen is brushed off.

So, every flower that the bee visits gets pollen from some other flower. Many kinds of flowers cannot make seeds and fruit at all unless bees carry the pollen. In this way bees and flowers work like partners. Bees get nectar and pollen that they need for food. The flowers get the pollen that they need so that their seeds will grow into new plants. Some other kinds of insects also help spread pollen among plants.

Animals help plants in another interesting way. You would probably never guess what it is. Suppose someone asked you this: "What is the plant's most dangerous enemy among the animals?" What would you say? Would you know that insects are the greatest enemies of plants?

If someone asked you what kind of animals protects plants against the insects, what would you answer? Do you know that birds are the greatest protectors of plants? Scientists say that if all the insects that are born were allowed to live, they would soon eat up all of the plants in the world. Many kinds of birds eat insects for food. In this way millions

of insects are destroyed every day. And in this way the birds help the plants to stay alive.

You will hardly believe some of the facts about the number of insects that birds eat. Scientists have figured that the birds in the state of Massachusetts eat about twenty-one thousand bushels of insects a day during the summer months of the year. Each bushel would have about one hundred twenty thousand insects in it. Scientists say that in New York State birds eat three million bushels of harmful insects every year.

While she was finding out how birds help plants, Mary Jane learned of another interesting way in which animals help plants. She told the class that one scientist called the earthworm a living plow. As you see in the picture, earthworms dig their way through the ground by eating soil. The soil goes in one end of the worm and out the other. In this way earthworms help to keep the soil loose, so that air and water can get down to [illegible] of plants. Perhaps you have seen little piles of dirt near holes that earthworms have made in the ground.

A scientist once figured out that an acre of good garden soil had fifty thousand earthworms in it. He also figured that eighteen tons of soil passed through the bodies of these earthworms every year. Perhaps you have thought that earthworms were good only for fishing, but you can now see that they help plants get the air and water needed by the plants to stay alive.

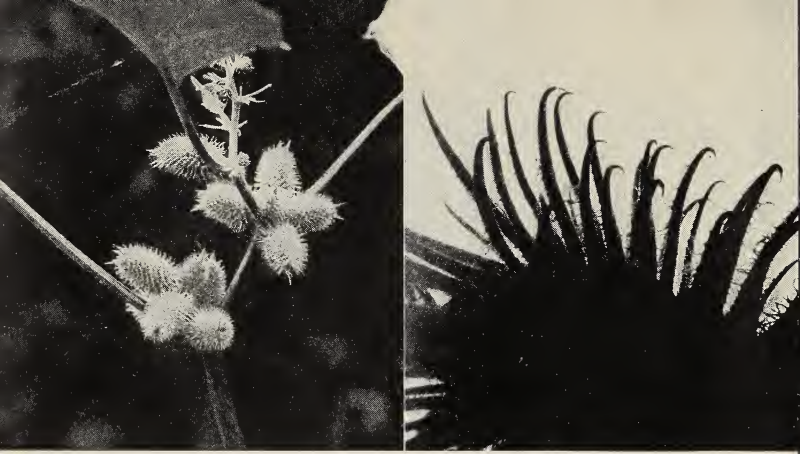
The day that Bill and John hiked through the fields and woods, they found that they had helped plants in a very funny way. They had not planned to help, and they did not notice how they were helping until they sat down under a tree to rest.

[illegible] at your trousers, Bill. They are covered with sticktights!" said John, as they sat down.

Bill laughed. "Look at them on the sleeve of your sweater, too."

The boys soon found many kinds of plant seeds sticking to them. As they picked the seeds off, they dropped them to the ground. Do you know what probably happened to the seeds?

Animals that have fur are the best carriers of these seeds that stick tight. They carry them far and wide until the seeds fall or are rubbed off. In this [illegible] seeds from one plant may grow into new [illegible] miles away. Did you ever pick burrs out of the fur in your dog's tail? Inside these burrs there were many seeds that probably sprouted and



The picture at the right shows the little hooks by which the burrs at the left catch your stockings and your dog's fur.

grew into plants in a new place far from the plant on which they once grew. Their free ride on your dog's tail helped them to spread. Seeds sometimes get faster rides than dogs and other four-legged animals can give them. They are carried far and fast by birds.

* * *

1. Tell exactly how bees and flowers are partners; that is, how each helps the other.
2. What are the most dangerous enemies of plants? What animals help protect the plants?
3. How do earthworms help plants?
4. Give one reason why you find the same kinds of plants growing in so many different places.

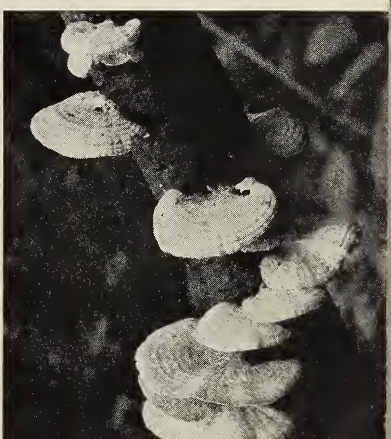
How do plants help other plants?

While the class was watching plants and animals to see how they help each other, the children were bringing to school many interesting things that they found out-of-doors. In the classroom were old birds' nests, a squirrel's nest, glass jars full of soil and ants, leaves that had been eaten by insects, and other things the children had found.

One day Henry brought to class some strange-looking things that he had found growing from the side of a tree. The picture on this page shows you what Henry found.

"It surely isn't an animal," said Henry. "And it doesn't look like a plant."

But it was a plant, even though it did not look green. This kind of plant shows one of the strange ways in which plants help other plants. This plant is called a *fungus*. There are many different kinds. You will find them growing on other plants. They cannot make their own food as green plants do; so they get food by using the food that the green plants have already made.



The fungus plant shows you that plants sometimes

How is this mistletoe getting water?

help other plants by supplying them with food. Mushrooms and puffballs cannot make their own food, either. They grow in the ground, but they get their food from plants that have died and decayed.

The mistletoe that we use for decoration at Christmas time must have the help of other plants. It can make food, but it does not get water from the soil. And of course it must have water to stay alive. So the mistletoe fastens itself to the branches of trees. As the water from the roots travels up through the tree, the mistletoe takes the water it needs.

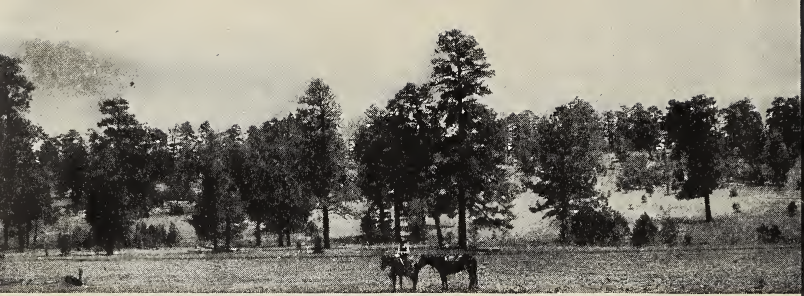
Did you ever find a jack-in-the-pulpit, like the one in the picture at the right? You will have to hunt in the damp, shady woods to find "jack." He will not grow in the bright sunlight. He must be protected by other plants. Ferns, too, need the pro-

tecting shade of larger plants around them. Many kinds of plants that cannot grow in the hot sun are helped by the shade of other plants.

Did you ever walk through a field that was once a forest? Perhaps some of the tree stumps were still standing. In a near-by woods you found many kinds of plants that you could not find in the field. These plants used to grow in this place, but as soon as the trees were cut down, the plants could not stay alive, because the shade was gone. Try to find out the names of plants that need a shady place to grow.

But some plants need the help of other plants to get sunshine. Look at the picture on this page. The vine has climbed up until it almost covers the tree. It is using the tree to lift itself up into the sunlight and the air.

One day while the science class was studying how plants help each other, Charles suddenly thought of something he had learned about how plants help each other. He had been on a camping trip in the mountains with his



What plants in the picture are the big trees helping? How are the big trees helping them?

uncle and cousins. There had once been a terrible forest fire that swept over those mountains and valleys. It was twenty years since the fire, but even yet there was hardly a tree more than a few feet high. There were only low bushes, small trees, grass, and tall dead trees without a branch on them.

"How long will it take for the forests to grow here again like the other forests we have seen?" asked Charles.

"About two hundred years," answered his uncle.

"But it doesn't take trees two hundred years to grow big," said Charles.

"I know," replied his uncle, "but the big trees protect the little trees and help them to grow. Now all the big trees are gone. The little trees start to grow. Then the wind, the rain, and the snow come, wash the soil away, and tear the little trees out by the roots. Or if there is a hot, dry summer, the sun beats down on the plants, dries up the water in the soil, and the young trees die."

"But some day it will all be forest again. A few sturdy little trees will manage to live somehow and grow big and strong. They will help other trees to get started, and the forest will spread over the mountains again."

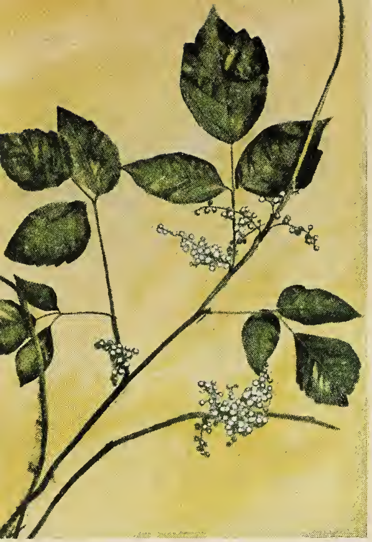
Every plant helps some other plant in some way. When the plant dies, it falls to the ground. Then it slowly rots away and becomes a part of the soil. The food materials in the plant go back into the soil and can be used again by new plants. Have you seen the black and spongy top-soil in a forest? This rich, loose soil is made mostly of decayed plants.

* * *

1. What is a fungus plant? Name some fungus plants.
2. Why must mistletoe grow on other plants?
3. How do plants help other plants get sunlight?
4. Why are plants in forests often different from plants that grow in open fields?
5. How do all plants help other plants get food?

How do plants harm other living things?

ONE MORNING Bill Bates came to school with his arms and hands almost covered with bandages. Everyone wanted to know what the trouble was. Sally thought he had been burned, but Bill explained that it was poison-ivy. He had been out on a



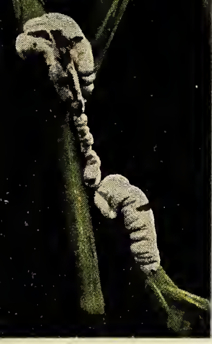
Notice that poison-ivy leaves grow in groups of three.

hike Saturday, and had sat down to rest. He had not noticed the poison-ivy on the ground.

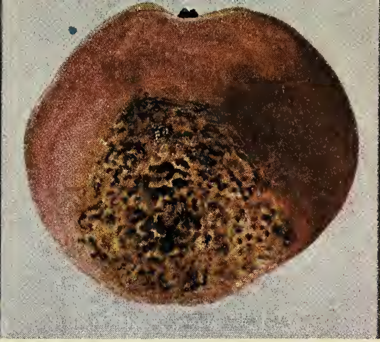
You have been discovering how plants and animals help each other. Bill's experience shows you that plants may also harm other living things. Perhaps you have been pricked and scratched by thorns. Those thorns scratch and tear any animal that brushes against them.

If you live on a farm, perhaps you know that cows sometimes become ill from eating a plant called white snakeroot. This plant poisons the milk of the cow. There are a number of kinds of plants that make horses, sheep, and cows act as if they were crazy, and finally kill them. Many kinds of plants will also make people very ill and sometimes kill them. If you are hiking out in the country, it is very unwise to eat berries or any other parts of plants unless you know that the plants are harmless.

The mistletoe that you read about on page 36 shows another way in which plants harm living



Corn



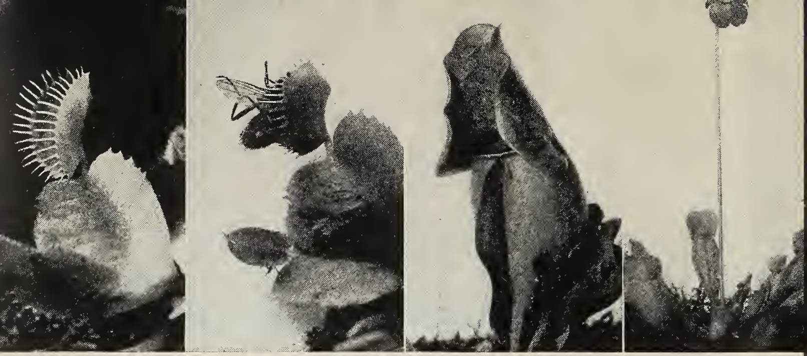
Apple

Plums

things. Mistletoe robs trees of water. If mistletoe grows too thickly on a tree, the tree will die. The fungus that Henry found growing on a tree was harming the tree by taking food from it.

There are many kinds of fungus plants. Some are tiny; some are big. Whenever they grow on living things, they are harmful because they are using the living things for food. Look at the pictures on this page. Do you see how the corn, the apple, and the plums have been spoiled? Tiny fungus plants have spoiled them. If you live on a farm, you probably know about such things as wheat rust, apple rust, potato blight, and corn smut. These are all caused by tiny fungus plants.

If you want to see what a fungus plant looks like, keep some bread moist for a few days. You will see mold growing on it. Mold is a fungus plant. Perhaps you have seen mold on old damp leather or on fruit that has spoiled.



You know that many kinds of insects eat plants, but you may be quite surprised to learn that some kinds of plants eat insects! One of these plants is called the Venus fly-trap, and its leaves make real insect-traps, as you can see in the two pictures at the left.

The leaves of the fly-trap are covered with a sticky liquid. If an insect alights on a leaf, it is caught in the liquid. Slowly the parts of the leaf fold over. They close tighter and tighter, until the insect stops wiggling. The fly-trap has done its work. It has caught another insect for the plant to eat!

A scientist once wanted to find whether one of these plants would eat other kinds of meat besides insects. He put a small piece of beef on the leaf. The leaf closed up, and next day the meat was gone. It had been eaten by the plant. The pitcher-plant, shown in the two right-hand pictures above, also eats insects.

One day Robert's father said to him, "Bob, some men are coming to take a tree down this afternoon. Perhaps you would like to watch them."

"Why are you cutting it down?" asked Robert.

"There are too many trees in our yard," answered his father. "I can't get any grass to grow, and the trees themselves cannot grow well. The trees shade the lawn, and there isn't enough water for them."

Robert knew what his father meant. Every green plant that grows needs to get enough water and food material from the ground to keep growing. Plants must also have sunshine so that they can grow. If plants are too close together, some of them take water and sunlight from others. The stronger plants may live, and the weaker ones may die. Weeds in your garden are enemies of your flowers and vegetables because the weeds take sunlight and water from them.

When plants grow farther apart, they are not shaded by each other's leaves; so there is plenty of sunlight for all of them. Their roots can find plenty of water, too. Where too many plants are growing close together, every plant is an enemy of every other plant. It is almost as if they were fighting each other for the things they need to keep them alive.

* * *

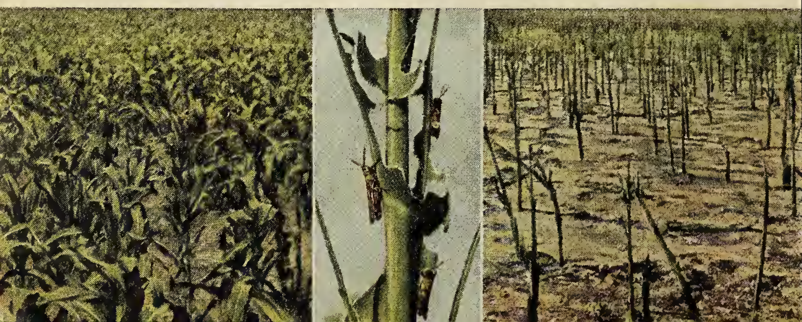
1. How may every plant be an enemy of every other plant?

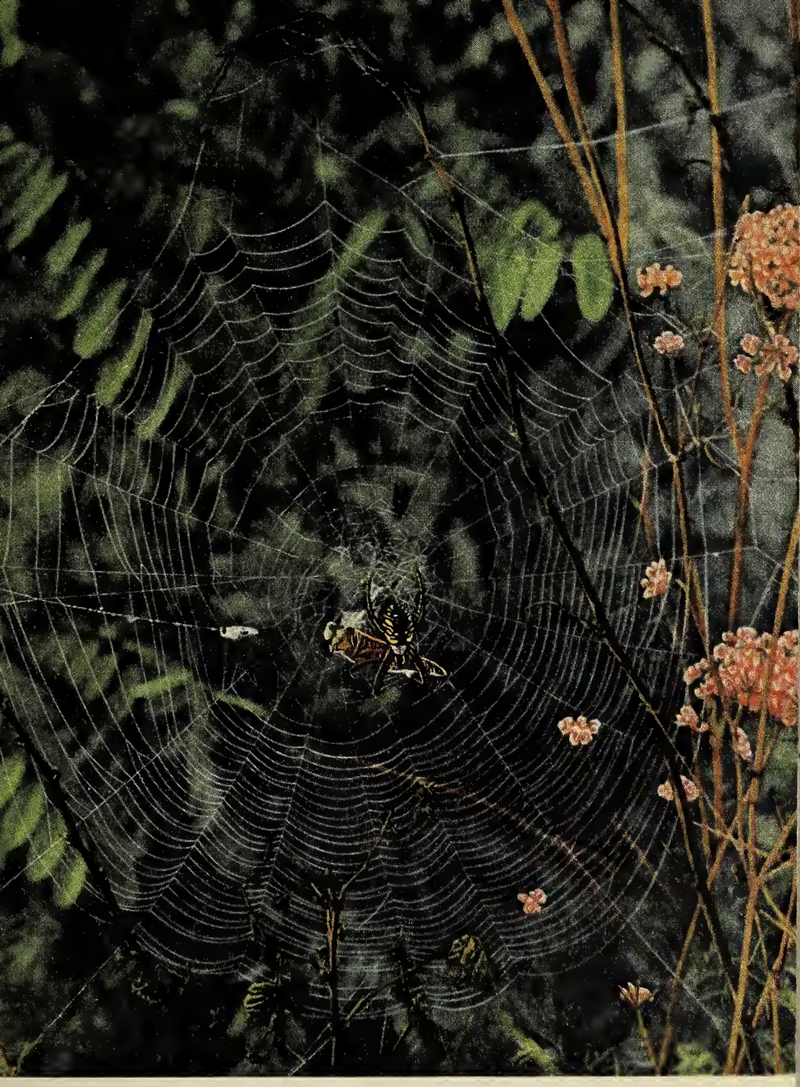
The weasel has killed a bird, and the porcupine is gnawing the bark from a tree. At the bottom of the page you see what swarms of grasshoppers can do to a corn-field.

How do animals harm other living things?

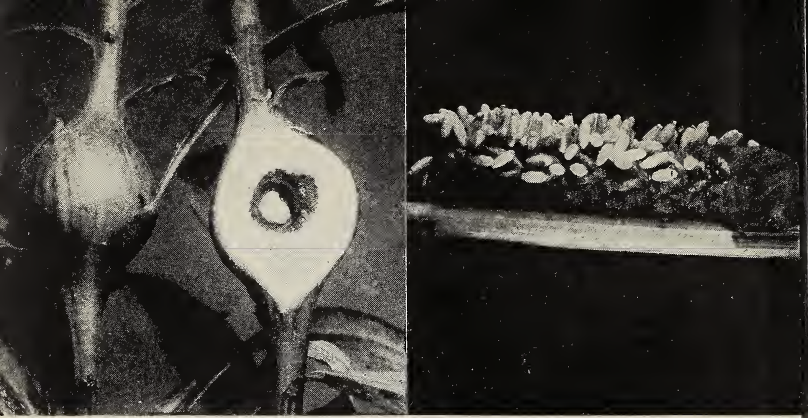
If you watch animals, you can easily see that they are spending most of their time hunting for other living things to eat. Rabbits eat the leaves of tulip plants just after the plants have grown an inch or two out of the ground. Rabbits also sometimes kill young trees by gnawing the bark off the trees.

Probably you have often seen leaves with big holes in them that had been eaten by insects. Of course you have read how grasshoppers by the millions sometimes light on a field of wheat or oats or corn and eat almost every plant growing in the field.





What does this picture show about the way living things help and harm each other?



Here are a plant and a caterpillar on which insects have laid their eggs. The eggs have hatched, and the young insects are eating the plant and the caterpillar.

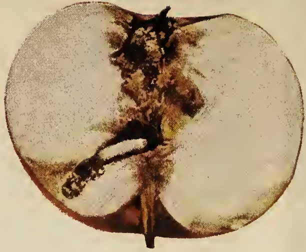
Look at the picture of the goldenrod stalk on this page. At one spot the stalk has swelled up into a ball about the size of a big marble. What do you think made this happen? When you cut the ball open, you find that some kind of animal has lived there. An insect has used the goldenrod stalk for a place to lay eggs, and one of the eggs hatched into a little worm-like creature. As this larva grew, the plant made the little ball around it. Many insects lay their eggs on the stems, roots, leaves, and flowers of plants so that the young insects can eat the plants when they hatch.

Some kinds of insects even lay their eggs on animals, and the newly-hatched insects eat the animals. There is a kind of fly that lays its eggs in the nose or on the lips of a horse. The newly-hatched insects find their way into the horse's stomach, where they fasten themselves to the lining of the stomach and eat it. If there are a great many of them, they may kill the horse.

The caterpillar in the picture on page 46 is being eaten by insects hatched from eggs laid on the caterpillar's body. An insect laid the eggs on the caterpillar and left them. When the eggs hatched, the young insects needed food. So they began to eat the caterpillar.

What do you think are the most dangerous animals in the world? Perhaps you would name lions, tigers, and snakes. You would be wrong. The most dangerous animals in the world are the insects. Is this hard for you to believe? Try to think how insects do harm to trees and other plants. Have insects ever damaged your garden or eaten your clothes? You will be able to understand why insects are so dangerous if you remember how insects grow.

The praying mantis is one of the few useful insects. It eats other insects. Dragon flies also help by eating mosquitoes.



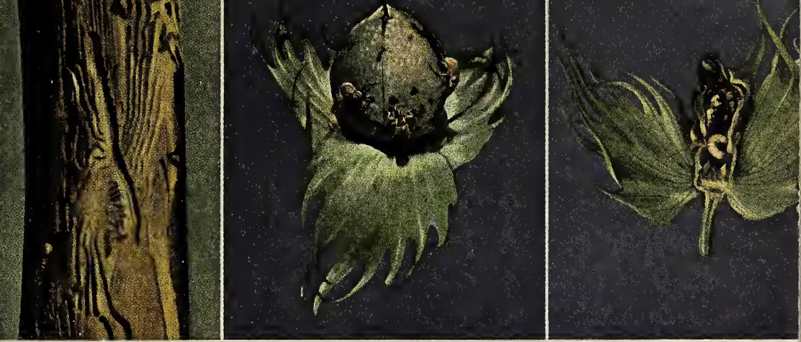
Both the apple and the cabbage leaves have been eaten by the larvae of some kind of insect.

Insects go through changes as they grow. Many insects look like little worms when they first hatch from the eggs. These worm-like creatures are called *larvae*. You may have seen larvae eating leaves of trees or feeding on vegetables in your garden.

Did you ever bite into a "wormy" apple? It was an insect larva that had spoiled the apple. The larva was probably hatched from an egg laid by a kind of moth. This moth lays its eggs on apples. In about a week tiny larvae hatch from the eggs and eat their way into the apple. They spoil the apple for us, and they may injure the seeds so that new apple trees cannot grow from them.

There are kinds of flies that ruin fruit and vegetables in much the same way that the moth ruins apples. They dig holes in the fruit or vegetable and lay their eggs in the holes. The larvae hatch from the eggs and eat the fruit or vegetables.

Other kinds of larvae that hatch from insect eggs eat the leaves of plants. There are cabbage-worms,

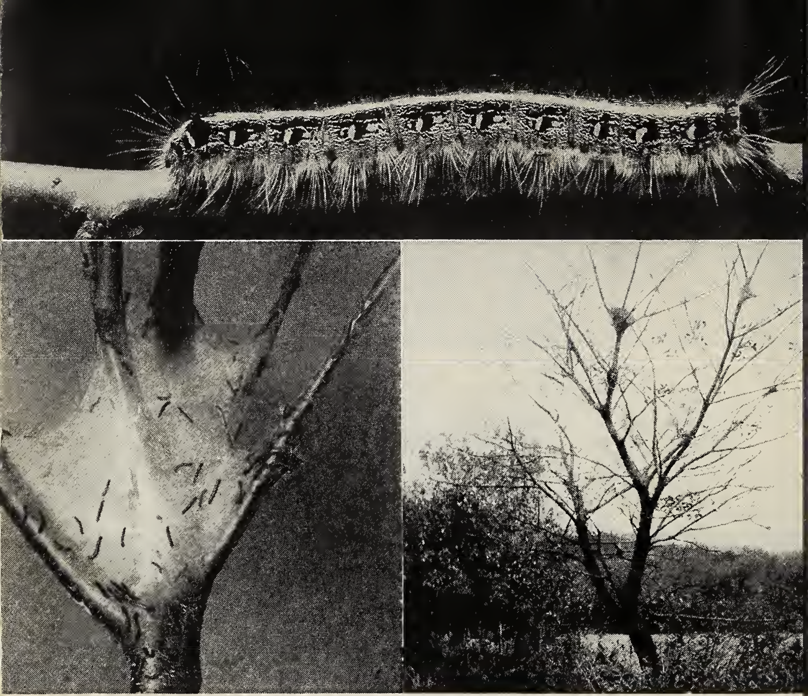


So many tunnels were made in the tree trunk in the first picture that the tree was killed. The other pictures show you how the cotton weevil harms cotton plants.

cutworms, and corn-worms. These are all insect larvae. Almost every kind of plant has some kind of larva that eats its leaves. The cutworm chews the stem of the plant just above the ground.

Many kinds of full-grown insects kill plants by sucking the sap from the plant. You know that plants need this sap for food. When too many of these insects get on a plant, the leaves turn yellow, and the plant dies. Other kinds of full-grown insects eat the leaves and even the wood.

Look at the pictures on this page. Do you see how insects have bored holes all through the wood? These holes were made by a kind of beetle. Millions of valuable pine trees have been killed by this beetle. If you live where cotton grows, you have heard of the boll weevil. This is a kind of beetle that kills cotton plants. The full-grown beetle



These caterpillars kill thousands of trees every year by eating the leaves. They are called "tent" caterpillars.

eats the leaves and lays its eggs on the part of the plant that grows cotton. The larvae that hatch from the beetle eggs eat the cotton.

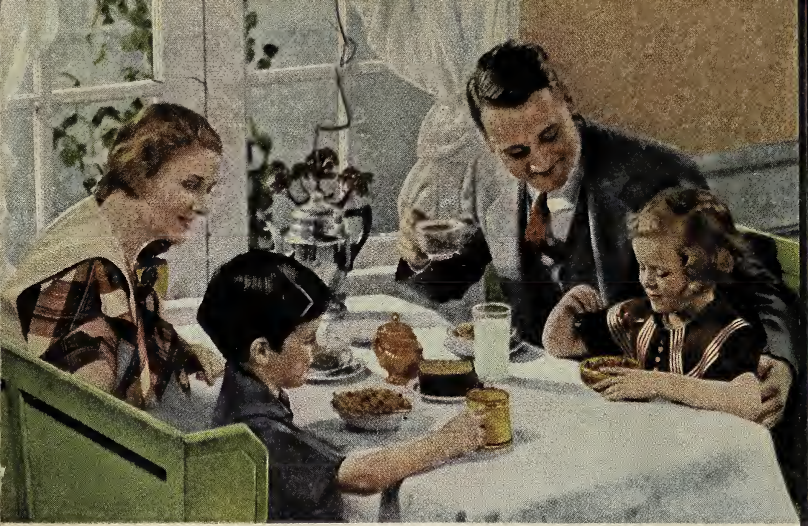
Scientists say that if insects were left alone, they would destroy all plants in the world in ten years. Can you imagine a world without plants? You know what would happen to all of us. We would have nothing to eat. There would be no fruit and vegetables, and there would be no cows, chickens, sheep, and pigs. These animals that we use for food must have plants for their food. They need grass, corn, wheat, oats, and other plants. Before you finish your study of this unit, you will find one way in which you can help fight our insect enemies.

* * *

1. What is the important reason why animals harm other living things?
2. Name five animals that you have seen harming other animals.
3. Name five animals that you have seen harming plants.
4. Why are insects the most dangerous animals in the world?
5. Tell three ways in which insects harm plants.

How do plants help us?

A SCIENCE class once made a list of all the different plants we use for food. They named over twenty-five plants. How many can your class name? Think of all the vegetables, fruits, cereals, and nuts you eat. Of course, if plants were gone, there would be no chickens, ducks, cows, sheep, and pigs, because they must have plants for food. Do you know that every year the people of our country eat millions of bushels of wheat, millions of bushels



What things in this picture came from plants?

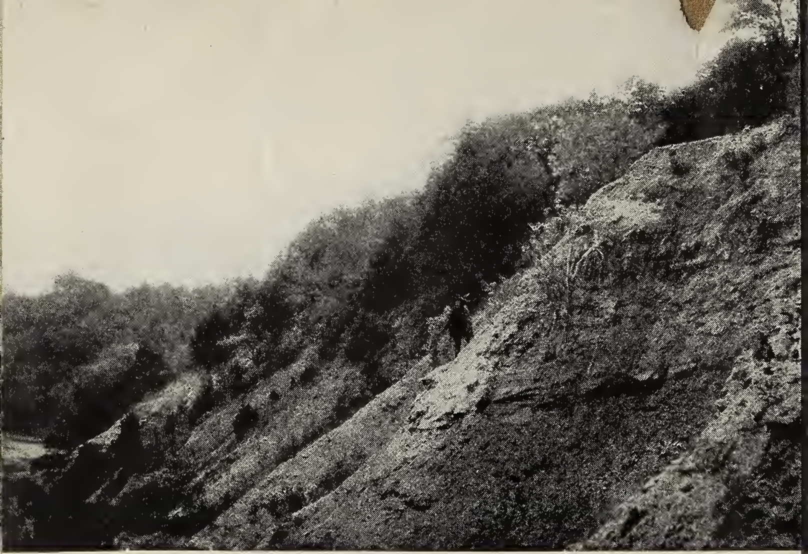
of potatoes, and millions of bushels of corn? In addition to wheat, potatoes, and corn we eat millions of bushels of apples, oranges, carrots, beets, and other fruits and vegetables every year.

But food is not all that we get from plants. Suppose you look around your school-room. Study everything in the room. What things come from plants? For example, is there any rubber in your room? The rubber was made from the rubber tree. Surely there is paint in your room. From one kind of pine tree we get something that helps us make paint. Can you find out what it is? Did any of your clothes come from plants? Of course there is wood in your room.

These plants are flax, cotton, and hemp. Linen is made from flax, cotton cloth from cotton, and rope from hemp. What things in your school-room come from these plants?

You can find another important use for plants if you talk to your druggist or doctor or the school nurse. Many kinds of plants are used to make medicine. Find the names of some medicines made from plants.

There is another very valuable thing that plants do for us. You would probably never think of it. Plants help to keep rivers from flooding over their banks. Dead leaves and stems and branches fall to the ground and make a soft, spongy covering for



Why does water run quickly from this hillside into the stream? What happens to the soil on this bank when heavy rains come?

the soil. When spring comes with its melting snow and heavy rains, the water soaks down into this spongy covering. The roots of the plants help to keep the soil loose, too, so that water can soak in. Where the soil is bare, some of the water soaks in, but most of it runs off quickly into the brooks and rivers. The brooks and rivers cannot hold it all; so they overflow their banks and flood the country.

Did you ever see a stream of water in the early spring when the snows were melting, or just after a long, heavy rain? What color was the water? It was yellow or brown, and muddy. Where did the mud come from? Perhaps you thought it came from the bottom of the river. But it really came from the land along the river. Rains are always washing soil into the rivers.

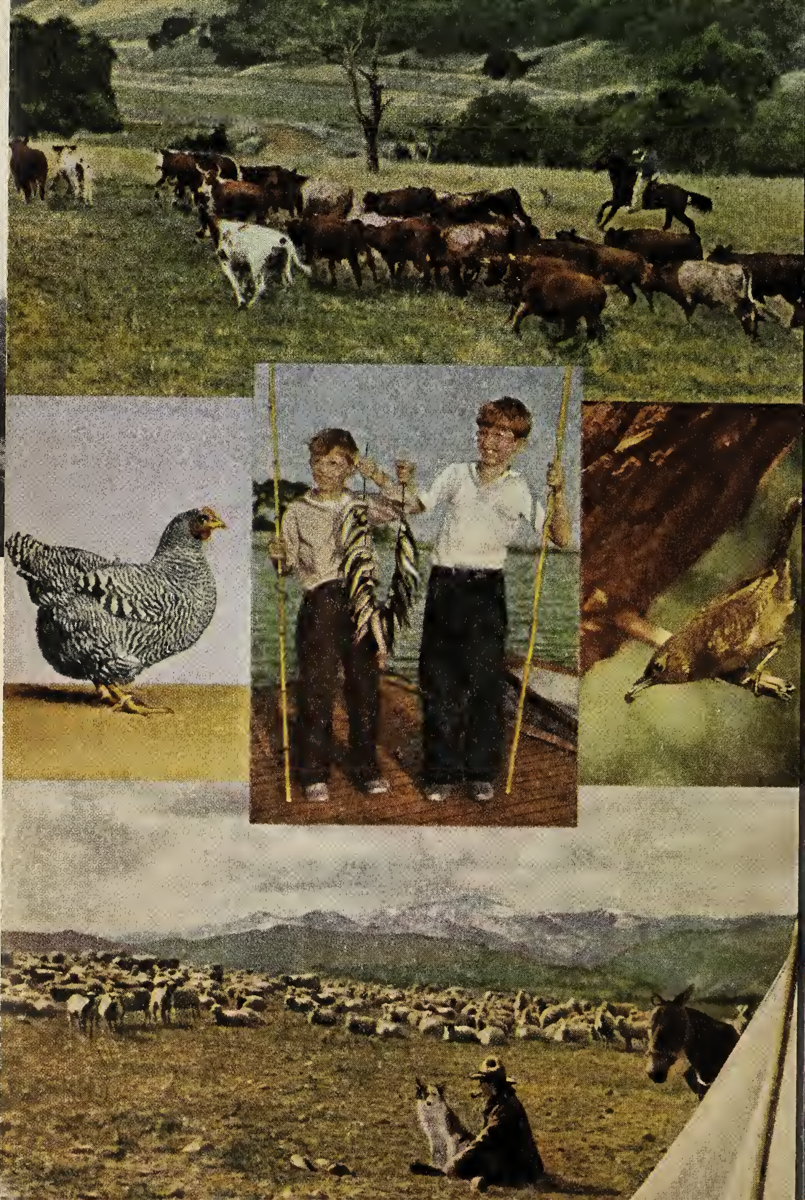
Plants help to hold the soil in place. With their roots, stems, and leaves they make a kind of protecting blanket over the loose soil. They keep it from being blown away by wind and washed away by water. In some parts of our country millions of acres of good farm land have been spoiled because men have killed the plants on hillsides. The rushing water from rains and from melting snow has kept carrying the soil away. Do you see how plants help us by holding the soil in place?

* * *

1. How many kinds of plants have you eaten yesterday and today? Name them. Tell what was done to them so that you could eat them.
2. What plants furnish you with clothes, carpets, curtains, and bedclothes?
3. How do plants help prevent floods?
4. How do plants protect the soil?

How do animals help us?

Even before you read the next few pages, you can probably tell ways in which animals help us. And if you observe things in the school-room, at home, and out-of-doors, you will find many more



answers to the question, "How do animals help us?" Your geography book, too, will give you answers to this question.

How many different kinds of animals helped to furnish you with food yesterday and today? Our meals would be very different if we did not have pigs, cows, chickens, sheep, oysters, and fish. Animals help furnish you with clothes, too. Silkworms, cattle, and sheep help you to keep warm and to look well dressed. Even alligators and snakes furnish us with skins for shoes, traveling-bags, and pocket-books.

Animals work for us and protect us, too. Horses, oxen, camels, and even dogs carry and pull loads for us. Dogs often protect us from enemies. Of course you already know how birds protect us from the insects that would soon destroy all our food plants. Most hawks and owls also protect our food plants. They kill rats, mice, ground-squirrels, gophers, chipmunks, rabbits, and many other small animals. These animals eat the roots, bark, and other parts of our fruit trees or eat the grains and vegetables from our farms and gardens.

Look at the pictures on page 56 and tell how these animals help us. You would probably never think of some of the strange ways in which animals help us. Glue is made from the hoofs, skins, and horns of animals. Animal hair is used in plaster to help hold the plaster together. Camel's hair and pig bristles are used to make paint brushes. Leather belts help to run machinery.

Of course this book can tell you only a few of the ways in which animals help you. There are many more things to learn. You can discover some of them by reading, asking questions, and observing things around you. Suppose you appoint five committees and have each committee take one of these problems to solve:

How do animals help supply us with food?
How do animals help supply us with clothing?
How do animals help us do our work?
How do animals protect us against other animals?

The fifth committee may hunt for things that do not come under food, clothing, work, and protection. The committees may help show what they have discovered by bringing pictures and samples of materials that we get from animals.

* * *

1. Name all the animals you can think of that:
a) supply us with food.
b) supply us with clothing.
c) help men work.
d) protect us against enemies.
2. Tell just what each animal does for us.

If you live on a farm, you know that plants and animals must be taken care of. They must have food and water, and they must be protected against enemies and disease.

How do we help the living things that help us?

DO YOU live on a farm? Or did you ever take care of a garden? Boys and girls who live on farms or who have gardens know many ways in which we help plants and animals. We provide food and shelter for our horses, cows, pigs, and chickens. We even have doctors for sick animals. We are just as careful with our food plants. With plows, hoes, and other machines we loosen the soil so that air and water can get down to the roots of the plants. We put fertilizer in the soil so that the plants will have materials to make food. We spray fruit trees and other plants with poison to kill harmful insects, and we fight the weeds that rob our plants of water, food materials, and sunlight.

Now let us see how and why we help many of our wild plant and animal neighbors. Did you ever hear the word *conservation?* It means saving or protecting something. Everywhere throughout our country men and women and even boys and girls are becoming interested in the conservation of our wild plant and animal neighbors. Let us see why it is so important to save the wild plants and animals.

For hundreds of years the people of our country have used their living plants and animal neighbors. They have cut down the trees to make houses, furniture, ships, and many other things. Millions of trees were cut down and burned so that the land could be used for farms. Wherever forests were cut down and bushes cleared away, many kinds of animals had no place to live. Men have also killed the wild animals and used them for food. Only about seventy or eighty years ago, millions of buffalo roamed the plains in the western part of our country. Today there are only a few thousand left.

Trees are among the most important of the living things that we are now trying to save. Our governments are spending thousands of dollars each year in planting new trees and in protecting

This forest burned and only black stumps were left. Government workers are planting young trees here.

the trees that are already growing. Thousands of acres of land are planted with new trees each year. In many places there are great forests where no trees are cut. In other forests the workmen are very careful not to harm the young trees when they cut down the large trees.

Forest fires have robbed us of millions of beautiful and useful trees. These same fires have killed countless wild animals. Our government has found

ways to help save our forests from fire. On this page is a picture of a tower in one of our nation's big forests. During the dry summer months a man stays in this tower and watches the forest for any signs of smoke. He can see for miles and miles across the tree-tops. There is a telephone in the tower, and if the man sees smoke from a forest fire, he telephones the message to men who will find the fire and put it out.

Lightning starts many forest fires, but most fires are started by careless men and women and boys

How can these boys keep their camp-fire from starting a forest fire like that in the second picture?

and girls. A lighted cigarette or cigar dropped in the grass or leaves may start a fire that will destroy thousands of trees and animals. Campers forget to put the camp-fire out, or they put it only partly out when they leave it. The wind begins to blow, and sparks fly out into the leaves and grass. A terrible forest fire starts. Are you careful with fire when you are in the woods?

What do you do when you see some lovely wild flowers? Do you pick them, or do you leave them for other people to enjoy? If you and everyone else pick the flowers, there will be no flowers for

Sometimes airplanes are used to cover forests with a spray that kills insects.

anyone to enjoy in a few years. Flowers make seeds, you know, and seeds make new plants.

Scientists are at work in many places studying the insects that harm the forest trees. They find out where these insects live, what they eat, and other facts about them. Then they work out ways of killing the insects before they do too much damage to the trees. Many hundreds of acres of trees have been saved by the work of these scientists.

Not so many years ago in our country there were flocks of beautiful passenger-pigeons. Today not one of these birds is alive. Men killed them by the thousands, and most of the forests in which they made their homes were cut down. There used to be thousands of heath-hens in the eastern part of our country. Today there is not one heath-hen left. People everywhere are worried because our wild ducks and geese are getting fewer and fewer.

To help save our wild-animal neighbors we have passed laws. These laws say that some animals may be hunted only a few days every year. The laws also tell just how many animals each hunter may kill. Ducks, geese, pheasants, bear, and deer are some of the animals that are protected by laws. Some animals have become so scarce, or they are so helpful to us that the laws say that no one shall ever kill them. In our country it is against the law to kill song-birds or birds that eat nothing but insects. It is also against the law to rob their nests of eggs.

Men and women who want to conserve our wild neighbors have helped them find homes for themselves. In many places in our country there are forests and swamps where no one is allowed to kill any kind of animal. Here the birds and other animals are safe to make their homes. You can help the birds near your home by planting trees and shrubs in which they can make their nests. You can also put up bird houses and feeding stands. You will be surprised when you see how quickly the birds learn to come to your yard for food.

* * *

1. What does the word *conservation* mean?
2. Tell three things that are being done to save our forests.
3. How can you help save forests?
4. What are we doing to protect wild animals?
5. What is causing many of our wild plants and animals to disappear?

Questions to Think About

1. Why are some kinds of insects called social insects?

2. What is the most important way in which plants and animals help each other?

3. Do plants need animals more than animals need plants? Explain your answer.

4. Why can man use plants and animals in more ways than any other living thing uses them?

5. Why do farmers plant corn, potatoes, and tomatoes in rows a foot or two apart instead of scattering the seed around everywhere?

6. In some parts of the world there are forests so thick that small plants cannot grow on the ground. Why cannot the small plants grow?

Things to Find Out

1. Find out how the following animals are helpful to man: sea-gulls, skunks, snakes, and toads.

2. Write a letter to the Commission of Conservation and find out what your province does to keep a supply of fish in the lakes and streams.

3. Read to find out more about the family life of bees and ants.

4. Prepare talks to show that:
a) Animals cannot live without plants.
b) Plants are helped by animals.
c) People need plants and animals.

5. Make a collection of pictures that show different ways in which we use animals and plants.

6. Ask your druggist or the school doctor to tell you about some of the plants that are used in medicine.

7. Send to the Commission of Conservation and get a film on forestry to show in your school.

8. Read about the life of beavers.

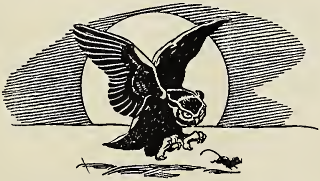
9. Try to discover other examples of how animals live together and report what you find to your class.

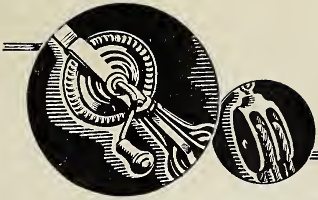
10. Make some bird houses and put them up near your home and school. Keep a record of the birds that nest in them. Perhaps you can take snap-shots of some of the birds.

11. Make a collection of plants that have been harmed by insects.

12. Make a list of rules that we should follow to protect trees.

13. Read to find out why mosquitoes made it almost impossible to build the Panama Canal.





UNIT TWO

HOW DO MACHINES HELP US DO OUR WORK?

What is a machine?

Do you know what a machine is? If you think you know, tell which of these things is a machine: orange-squeezer, egg-beater, bicycle, knife, wheelbarrow, plow, windmill, can-opener, saw, hammer, scissors, broom, pencil-sharpener. Perhaps you will be surprised to learn that each of these things is a machine. When you think of a machine, you probably think of something like an automobile, or a steam locomotive. These are machines, too. But a can-opener or a hammer is just as truly a machine as a bicycle or an automobile.

A hammer, a pencil-sharpener, and a bicycle do not look alike. Machines may be of all shapes and sizes. There is, however, one way in which all machines are alike. Every one of them can be used to help us do our work. A machine is a helper. Nearly all of our work is done with the help of machines. They help us cut, mix, bend, straighten, lift, push, and pull things. Machines make work easier for us, as you will learn in this unit.

The wrench is a machine. It helps the man make the bolt very tight.

Of course, a machine will not work by itself. A pair of scissors lying on the table does not jump up and cut a piece of cloth. Some *force* must be used to make a machine work. We may use the force of our muscles or the muscles of some animal. We may use the force of electricity, or of wind, or of water. But some force must always be used to make the machine work.

You can do many things with machines that you cannot do without them. Can you pull a nail from a board with your fingers? You are not strong enough to do this. But it is easy to pull the nail with a claw-hammer. By using a very little of the force of your muscles on the claw-hammer, you can pull the nail from the board.

Now cut an orange in two and squeeze out the juice of one half with your bare hand. Then use an orange-squeezer to get the juice from the other half. Did the orange-squeezer make it easier to get out the juice? Because it made your work easier, the orange-squeezer is a machine.

How do these machines save force?

When we use machines, we do not need so much force to do our work. Without machines, we might not have enough force to do some things, such as lift a very heavy stone. Machines make work easier for us because they save force.

Big machines, and even some little machines, are made of many different parts. You know that steam locomotives, gasoline engines, bicycles, watches, and sewing-machines have many parts. But do you know that these machines are all made of *simple* machines put together in different ways? In each simple machine there are only one or two parts.

If you could take a watch and an automobile apart, you would find the same kinds of simple machines in each one. Let us see what these simple machines are and how we use them to make our work easier.

How do pulleys help us do work?

One of the kinds of simple machines is called a *pulley*. Do you know what a pulley looks like? It is just a wheel fastened between two pieces of iron or wood to hold it in place. It is fastened so that it can turn easily. Usually the wheel has a groove in the rim to keep the rope or chain from slipping off. Sometimes pulleys are made of wood and sometimes of iron.

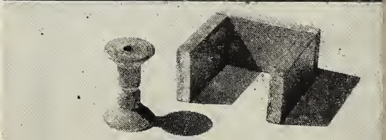
To see how a pulley helps you work, you will have to do some experiments. Hang a pulley up and put a piece of strong cord over the pulley wheel. Fasten a small weight on one end. Now pull down on the other end of the cord. As you pull down, the weight moves up. Can you think of ways to use a machine like this? Try to think of some places where you have seen pulleys at work.

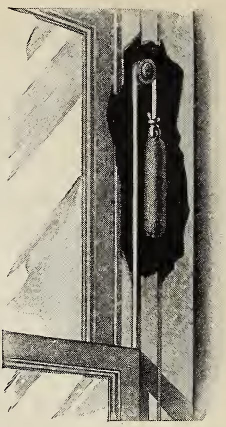
Now fill a gallon pail or a basket with rocks or other heavy material. Then lift this weight above your head. That was not very easy to do, was it? Now see if you can lift it more easily by using a pulley.

Put a small rope over the pulley. Be sure that the rope is long enough so that both ends touch the floor. Tie one end of the rope securely to the handle of the pail or basket and pull down on the other end of the rope. Keep on pulling until the weight is lifted above your head. Was it easier to lift the weight when you used the pulley? It is easier to pull down than to lift up. With the pulley you found that it was easy to lift the weight higher than your head.

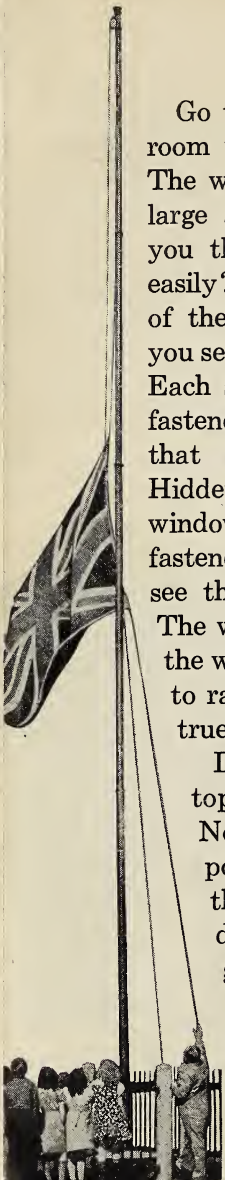
If you do not have a pulley, you can easily make one. Get a strong spool and a large nail that will slip easily through the hole in the spool. Then get three small pieces of wood. Drive the nail through one of the boards. Put the nail through the hole in the spool, and then drive the nail through another piece of wood. Leave enough room between the spool and the boards so that the spool will turn easily. Connect the two pieces of wood at one end with another board for a crosspiece. Put a screw eye in the crosspiece so that you can hang the pulley up, as shown in the picture.

A pulley used in this way is called a *fixed pulley* because it is fastened. It stays in once place, and only the rope and the weight move. There are a number of fixed pulleys in your school-room. Do you know where some of them are?

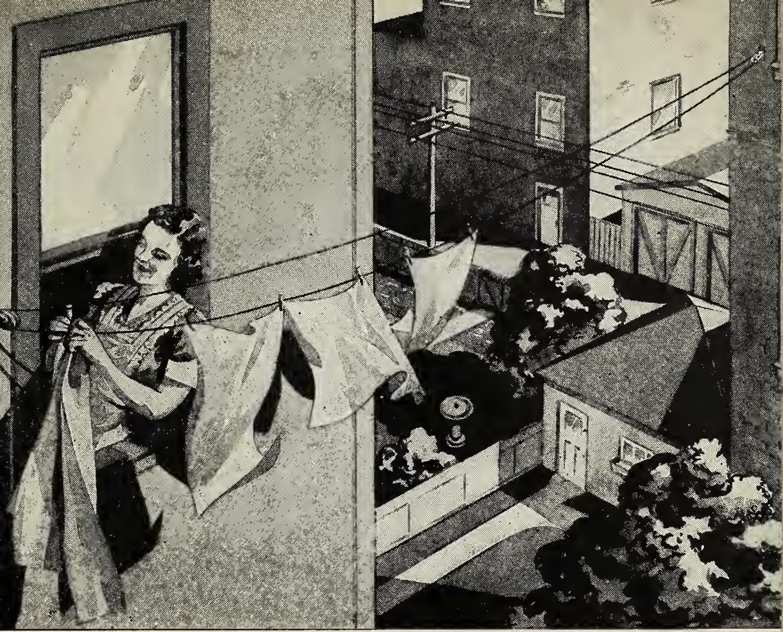




Go to one of your schoolroom windows and raise it. The window probably looks large and heavy. Why do you think you raised it so easily? Look up at the top of the window casing. Do you see pulleys on each side? Each side of the window is fastened to one end of a rope that goes over a pulley. Hidden in each side of the window casing is a weight fastened to the other end of the rope. Do you see the weight and the rope in the picture? The weight is almost heavy enough to pull up the window. It takes just a little of your force to raise the window. Do you see why this is true?

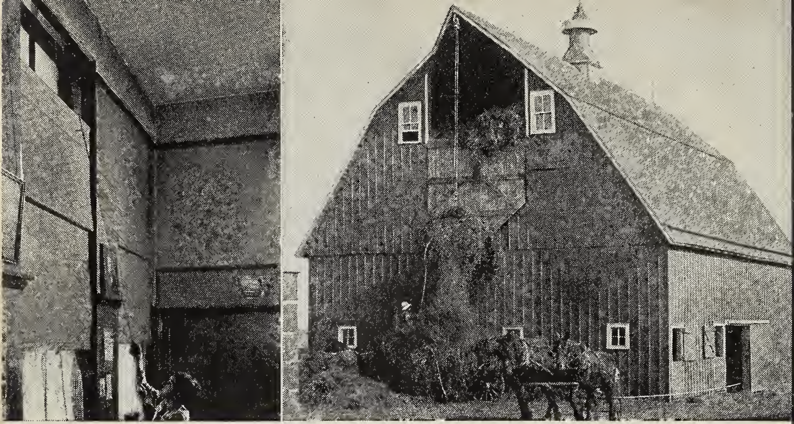


Do you know how to get the flag to the top of the flag pole in your school yard? No one climbs the pole. Before the flag pole was put up, a pulley was fastened to the top of the flag pole. All you need to do is to fasten the flag to the rope that goes over the pulley. Then if you pull on the rope, up goes the flag to the top of the pole!



Look at the picture on this page. Do you see how two fixed pulleys help move the clothes-line? This woman lives high up in an apartment-building. There is no room in the yard for her clothes-line; so she dries clothes high up in the air. One pulley is fastened near the window. Another pulley is fastened to a building on the other side of the yard. The woman stands at her kitchen window, pins the clothes on the line, pulls the rope, and away go the clothes out into the air.

You may have seen banners stretched across the streets of your town. Probably they were put in



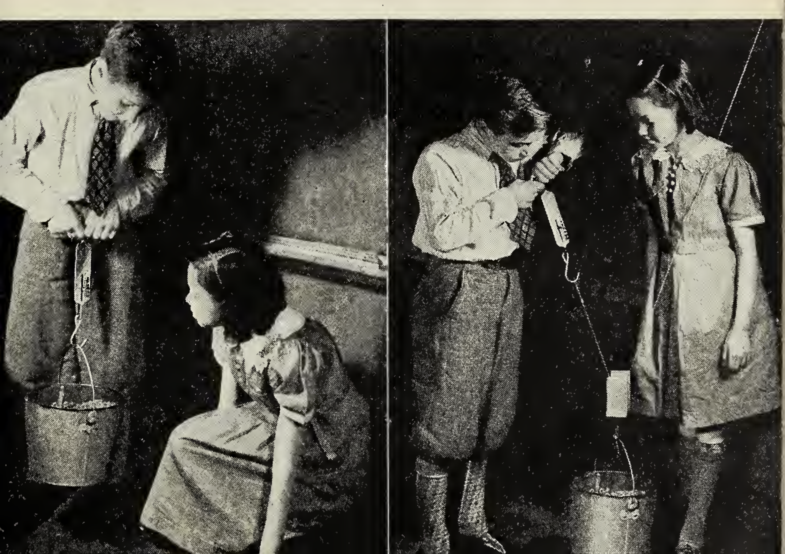
How do pulleys help in these two pictures?

place by use of fixed pulleys. Can you tell how the pulleys were used? One of the pictures above shows how fixed pulleys are used to carry hay up into a barn. There is a fixed pulley at the top of the barn. Another pulley is near the ground just inside the open door. Can you see the rope that the horses are pulling? When they pull the rope sideways, the bundle of hay travels up to the opening near the top of the barn.

Fixed pulleys help us to move things to places where we want them. A different kind of pulley helps us work in another way. An experiment will show you how this kind of pulley works. First, fasten a piece of heavy cord to a hook or nail high up on the wall. Then attach a weight to a pulley and put the cord through the pulley. As you pull up on the cord, the pulley moves up, carrying the weight with it. A pulley used in this way is called a *movable pulley* because it moves along the cord.

If you do an experiment and think carefully, you can discover how a movable pulley makes work easier. Fill a pail with stones. Weigh the pail of stones on a pair of draw scales. How many pounds does it weigh? Now fasten the pail to the pulley and tie the end of the cord to the draw scales. By pulling up on the scales, you can lift the pail.

Read the scales and tell how much muscle force it takes to lift the pail when you use the movable pulley. How much force did it take to lift the pail without the pulley? Does it take more force or less force to lift the pail with the pulley? How does this pulley help you work? The hook or nail

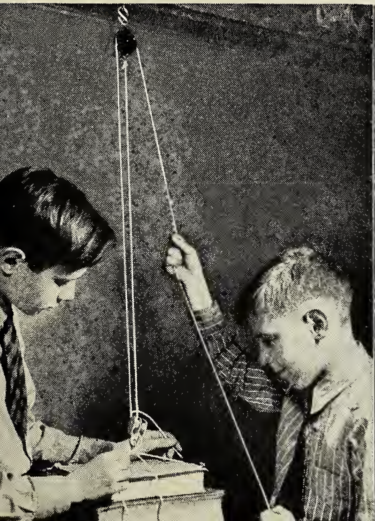


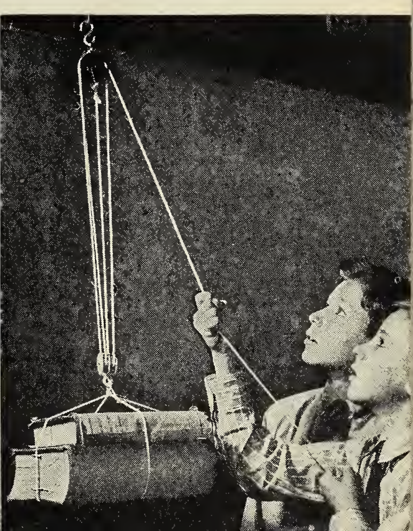
to which the cord is fastened holds up half the weight; therefore you need to lift only about half the weight.

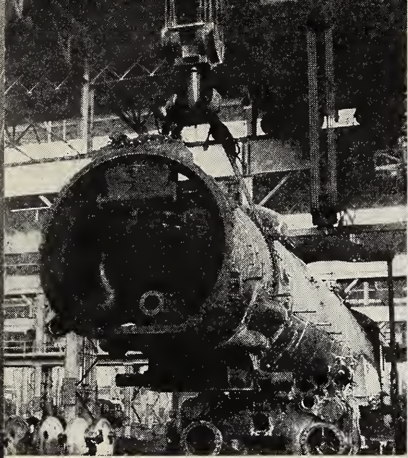
The movable pulley is an example of how a machine can help you lift a heavy weight with a small force. If you lift ten pounds with a fixed pulley, you have to pull with a force of about ten pounds. But if you lift ten pounds with a movable pulley, you have to use a force of only about five pounds.

Often several pulley wheels are placed side by side between two blocks of wood or iron. This is called a *pulley block*. Two pulley blocks and the ropes that connect them are used to make what is called a *block and tackle.* The pictures at the top of page 78 show how a block-and-tackle machine is used.

The more pulley wheels there are in the block, the easier it is to lift the load. You can see that this is true if you try this experiment. Use one fixed pulley and one movable pulley to lift a weight, as shown in the first picture below. With the draw scales measure the amount of force you used. Then use a fixed pulley block with two pulley wheels and a movable pulley block with two wheels, as the boys in the second picture are doing. Do you see how the rope is put through the pulleys in the picture? Now lift the weight by pulling down on the rope. Was it much easier to lift the weight when you used several pulleys?







Pulley blocks are used in cranes and derricks to lift heavy loads, such as big pieces of steel. They are also used to lower and raise life-boats on ships, to lift pianos to the upper stories of buildings, and to raise elevators in tall buildings. Do you see the pulleys in the pictures above? In the picture at the right they are fastened to a life-boat so that it can be raised or lowered. In the other picture they are being used to lift part of a locomotive.

Now let us see what we have learned about a pulley. With a single fixed pulley we can move objects higher than our heads by pulling down on a rope. This is much easier than lifting the object. We can also move things to places where it is difficult to go, like the top of a flag pole. When we have a movable pulley or several pulleys together, we can lift heavy objects with a small force. A pulley is surely a machine, because it makes the work of moving heavy things much easier.

* * *

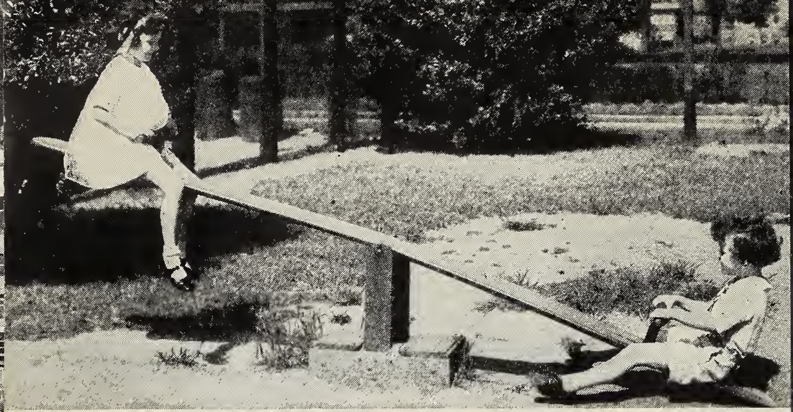
1. Tell two ways in which pulleys make work easier.
2. How could you lift fifty pounds by pulling with a force of only about twenty-five pounds?
3. What is a pulley block?
4. If an object is very, very heavy, would you use one movable pulley or several pulleys to lift it? Why?

How do levers help us do work?

CAN YOU PULL tacks out of a board with your fingers? Can you crack a hickory-nut in your hand? Or can you easily lift the heaviest boy in your class?

You know that it would take a great deal of strength to lift the heaviest boy in your class. With a simple machine, however, you can easily lift him. All you need is a long plank and a thick stick of wood. Can you imagine how these things would make a machine to help you?

You can use this machine by putting the stick of wood on the floor and placing the plank across the top of it. Place the plank across the stick so that twice as much of it is on one side of the stick as

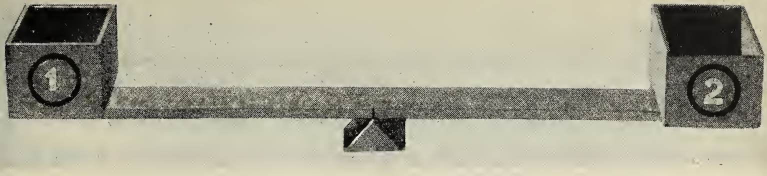


The boy weighs more than the girl. What can she do in order to lift him?

there is on the other side. Now have the heaviest boy stand on the short end of the plank. You push down on the other end. What happens? This machine that you have just used is called a *lever*. By using this lever you can make a small force lift a heavy weight.

Did you ever play on a seesaw? When your weight forces your end of the seesaw down, you move the other child several feet up into the air. The seesaw is a lever. The board of the seesaw is held up by a support. This support is called the *fulcrum* of the lever. The stick of wood under the plank you used to lift the heavy boy made the fulcrum of that lever.

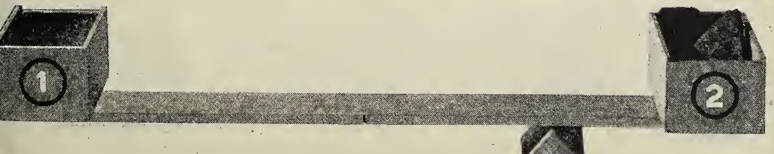
Let us now do an experiment to find out more about how to use a lever. Get a board about three

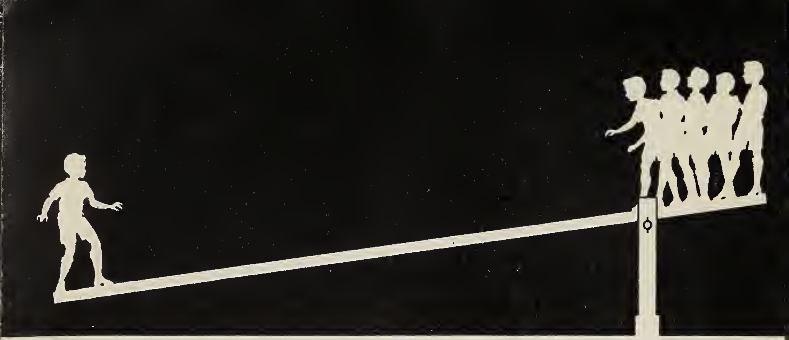


inches wide and three feet long. Use a small, three-sided block of wood about two inches high as a support for the board. This support makes the fulcrum of the lever. First, balance the board on the fulcrum. Draw a line across the board at the place where the board balances. Now put an empty chalk box on each end of the board. Put sand in the boxes until they each weigh one pound. If they do not balance, put a little more sand in the lighter box to make them balance.

Now move the board so that one-fourth of it is on one side of the fulcrum and three-fourths is on the other side. Do the boxes balance? Add rocks or sand to the box on the short end of the lever until the boxes balance. Now weigh the box on the short end. Does it weigh about three pounds? Do you see that the one-pound box on the long arm of the lever is balancing a three-pound box on the short end?

What does this tell you about using a lever? The weight that you want to lift should be as close to the fulcrum as possible.





Look at the picture above. One boy is lifting five boys. Why can he do it?

Do you see how you can use a lever to lift a heavy stone? A long iron bar and a small stone are all that you need. How can you use these to lift the heavy stone with as little force as possible? First put one end of the bar under the big stone. Then put the small stone under the bar so that the bar rests on it. This makes the fulcrum of your lever. If you place the small stone as close to the large one as possible, you can lift the large stone more easily.

If you try to pull a tack with your fingers, you probably cannot get it out. Try pulling it with a tack-puller. It is easy to pull a tack that way, isn't it? The tack-puller, too, is a lever. Let us examine it to see why it is a lever. When you put the tack-puller in position, notice that part of it rests on the board. You push down on the handle to pull the tack. You lift the tack up with one end

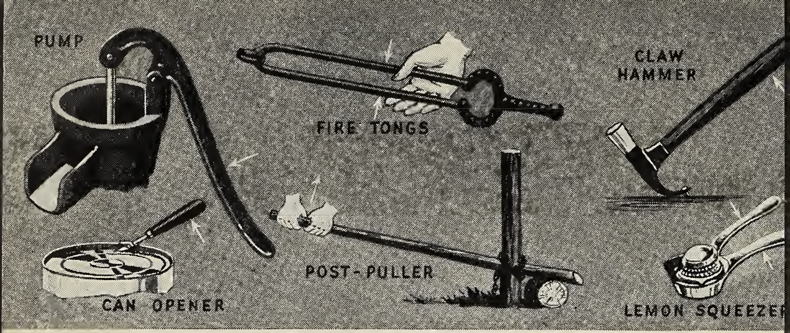
Tell where the fulcrum is. Where is the force?

of the tack-puller by pushing down on the other end. The fulcrum of the lever is the spot where the tack-puller presses against the board.

Let us now examine some other levers. Break a nut open with a nutcracker. Notice where you use the force when you crack the nut. You press the ends of the two handles. Where is the fulcrum in this kind of lever? The fulcrum is a hinge at the other end of the nutcracker.

Often in tools you will find that the fulcrum is at one end and the force at the other. The object that you are trying to move or break is between the force and the fulcrum. When you squeeze a lemon in a lemon-squeezer, you use force on the handles. The fulcrum is a hinge at the other end, and the work of squeezing the lemon is done between the fulcrum and the force. See the picture on page 86.

Pick up a lump of sugar or a piece of coal with a pair of tongs. Where do you use the force on this lever? Notice



where the force is used when you press a pair of tweezers together. These examples show that sometimes the force is used between the fulcrum of a lever and the place where the work is done.

Now think of all the levers you have used. Do you see that each lever has three parts? The three parts of a lever are—a fulcrum, a part where force is used, and a part where the work is done.

1. In each picture above, tell where the force is and where the fulcrum is.

2. Which makes it easier to lift a weight with a lever—weight far from the fulcrum or weight close to the fulcrum?

3. If you are playing seesaw with someone much heavier than you are, how would you arrange the board? Why? If you could not move the board, would you have the heavier person sit near the fulcrum or near the end of the board?

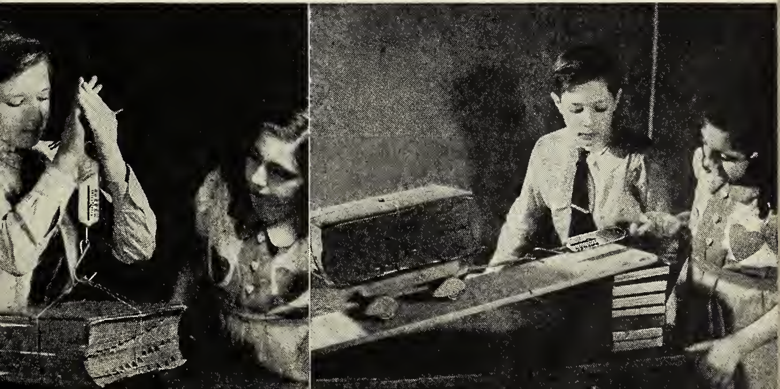
4. How could you prove that a force of five pounds can lift a weight of fifteen pounds?

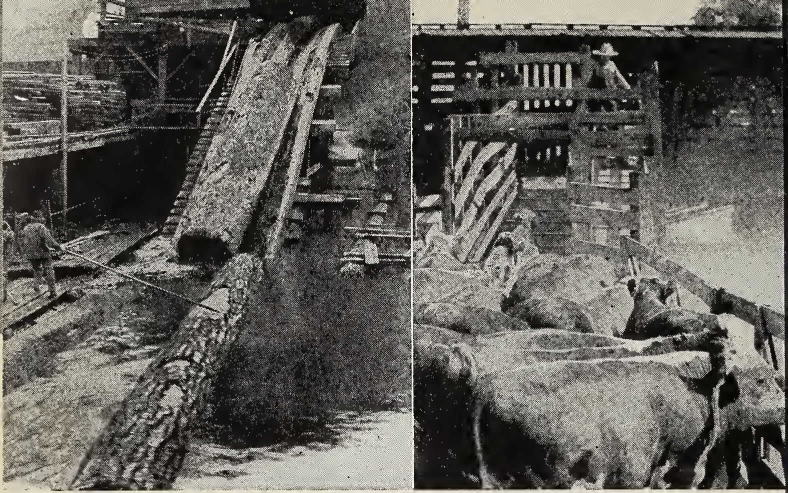
How do inclined planes help us?

ANOTHER KIND of simple machine is called an *inclined plane.* A plane is a flat surface. The floor of your school-room is a plane, and so is the top of your desk or a table. A plane that is sloping, or slanting, is called an inclined plane. The floors in theaters are often sloping, or slanting; so they are really inclined planes.

You can make an inclined plane by following these directions. Get a board three or four feet long. Let one end rest on the table and put the other end up on a stack of books or a box about a foot high. Because the board is sloping, or inclined, it is now an inclined plane.

Let us see how this machine can help us do work. First, tie a heavy cord around a big dictionary or something else that is heavy. Then lift this dictionary or weight straight up by the cord and put it on top of the box or stack of books. Was it hard



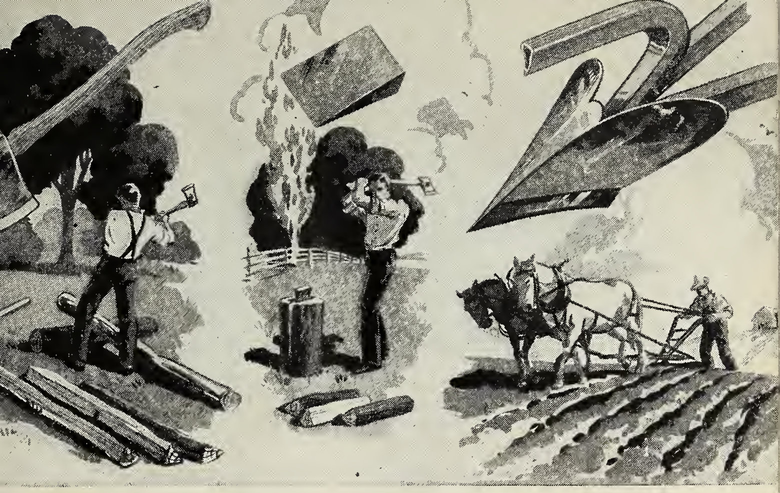


The first picture shows an inclined plane on which big logs are pulled into the sawmill. How is an inclined plane being used in the second picture?

work to lift the dictionary up there? Weigh the dictionary. How many pounds does it weigh?

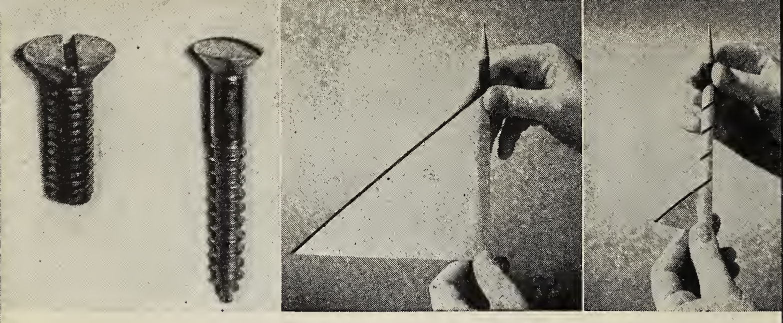
Now put the dictionary at the foot of the inclined plane and pull it to the top. Was it easier to pull the dictionary up the inclined plane than to lift it straight up? To see how much less force it takes with the inclined plane, use the scales to pull the dictionary up. Read the scales as you are pulling. How many pounds of force did it take this time?

Now try the experiment in another way. Put the dictionary on a toy wagon and use the scales to pull it up the inclined plane. Did you need less force this time to pull the dictionary up?



You can easily see that inclined planes are machines that help us lift things more easily. You have probably seen men rolling barrels or sliding boxes up an inclined plane into a wagon. Cattle walk up an inclined plane when they are loaded into railway cars. If you go up a hill or a mountain in an automobile, you are using an inclined plane to get to the top.

Look at the picture of the ax, the wedge, and the plow. Study these machines carefully. Are they like any other machine you have studied? Suppose you lay an ax or a wedge on one of its flat sides. Does the other flat side make a little inclined plane? How many inclined planes are there in an ax or a wedge or a plow? Axes and plows are kinds of wedges, and a wedge is just two inclined planes

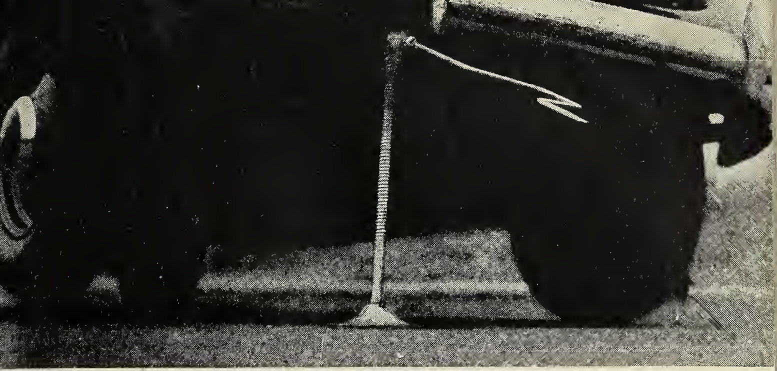


joined together. When you drive an ax downward into a piece of wood, the wood splits sideways. As plows are pulled forward, they push the soil sideways.

Now look at the pictures of screws on this page. Would you imagine that a screw was an inclined plane? Take a piece of paper and cut a triangle from it. Stand the triangle on one of its sides. Do you see that one side of the triangle makes an inclined plane? Now wrap the triangle around a pencil. Does the edge of the paper make a line around the pencil like the edge of a screw?

A screw is just an inclined plane that winds around as it climbs. If the screw were big enough, you could start at the bottom and walk up the winding inclined plane to the top. Jack-screws, such as you see in the picture on the next page, help us lift weights that we could not lift without them.

You can see that we use inclined planes to help us work. They help us lift heavy things. They help us split things apart. That is what happens

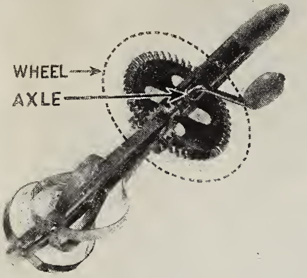


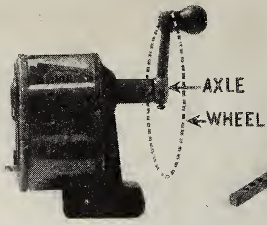
when an ax or a wedge splits a piece of wood or when a plow makes a furrow in the soil.

1. How could you prove that it is easier to pull a load up an inclined plane than to lift it straight up?
2. Name two machines that are made from inclined planes. Show how each one is made of inclined planes.
3. Name five examples of inclined planes that you have seen used. Tell how each one made work easier.

How does the wheel and axle help us?

YOU KNOW so much about *wheels* that you could probably tell how they help us without even reading this book. Someone once said that the wheel was the most important machine ever invented. It is almost impossible to imagine a world without wheels. But the Indians never learned how to make a wheel and fasten it on a rod or *axle* that

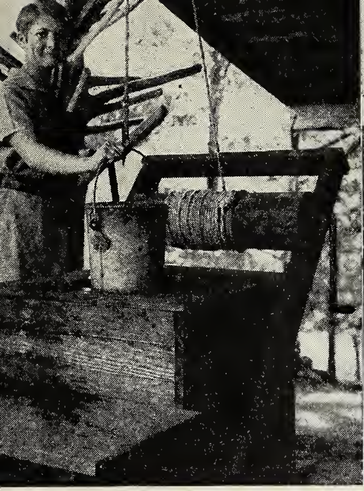


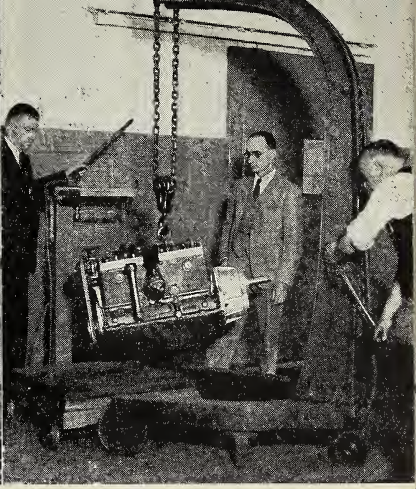


passed through the middle of the wheel. There are savage tribes in Africa today who never use wheels. They use levers and inclined planes, but no wheels. Of course they do not use pulleys, because a pulley has a wheel in it.

You probably have several wheel-and-axle machines in your school-room. Perhaps you have never thought of them as wheels because some of them do not have spokes like other wheels. The door knob is really a wheel. It turns the rod, or axle, to which it is fastened, and this moves a catch inside the door. Your pencil-sharpener may use a wheel, too. Instead of turning the entire wheel, you turn one spoke of a wheel. This spoke is the handle. The handle turns the sharp blades inside. The handle of a clothes-wringer is really a spoke of a wheel, too. An egg-beater is also a wheel-and-axle machine.

You can see how a wheel and axle helps you if you take a door knob off and try to open the door



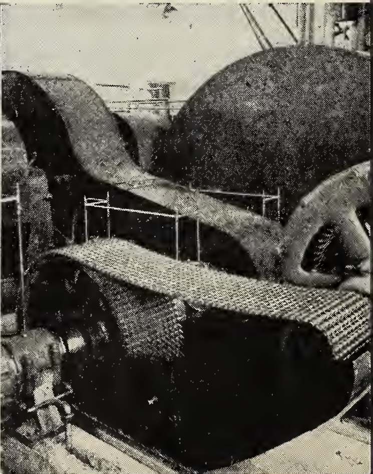


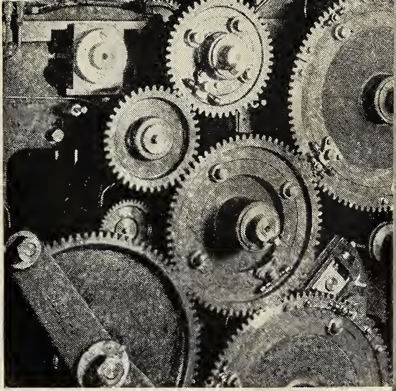
by turning the rod with your fingers. Does the knob make it easier to turn the rod? Could you sharpen a pencil if the handle of the sharpener were taken off? The steering-wheel of your father's automobile is also a wheel and axle. Do you think you could steer an automobile by the rod that the steering-wheel is fastened to? When a big wheel is fastened to a small axle, a little force on the big wheel will move a heavy weight attached to the axle. That is one reason why we use the wheel and axle in so many ways.

Perhaps you have seen an old-fashioned well in which a bucket is let down and drawn up full of water. A wheel-and-axle machine is used to make this easier, as shown in the first picture above. In the other picture a man is using a wheel and axle to lower a heavy automobile motor. One man can move a very heavy weight with this machine.

Wheels help us in another way. With wheels we can change one kind of motion into another kind of motion. When you ride a bicycle, your feet go around in a circle, but the bicycle moves forward in a straight line.

While men were learning how to use the wheel-and-axle machine, they found that they could make one wheel turn another wheel. They did this by putting a tight band around two wheels. This band is called a *belt.* When the first wheel is turned by machinery, the connecting belt turns the second wheel. Can you find a belt connecting two wheels on a sewing-machine? Your bicycle chain is really a belt and so is the big chain that you see in the second picture.





Men also found that they could make one wheel turn another wheel if they put the wheels tightly together, rim to rim. But often the wheels would slip. So someone thought of a way to keep them from slipping. He cut notches in each wheel. The notches on one wheel fitted into the notches of the other wheel. The points of the notches are called *teeth*. A wheel like this is called a *gear* or a *gear-wheel*. Gear-wheels cannot slip. Study the picture on this page to see how one gear-wheel turns another.

In an egg-beater notice how the teeth of the big wheel fit into the teeth of the little wheels. Turn the handle of the egg-beater once around. How many times do the little wheels turn? Do they go faster or slower than the big wheel? Do you see how gear-wheels help us change speed? A big wheel turning slowly will make a little wheel turn rapidly.

We use wheels for many things. Wheels that are fastened to axles help us use a small force to move a heavy weight. Wheels that are connected with each other by belts help us to make one machine run other machines that are many feet away from the first machine. Wheels also help us turn other wheels with greater speed.

* * *

1. Tell two ways to make one wheel turn another wheel.
2. Suppose you wanted to change your bicycle so that it would go very fast. Would you put a larger wheel where the pedals are, or a smaller wheel?

How can we make machines work better?

YOU KNOW that it is easier to walk on a dry sidewalk than on an icy sidewalk. When you walk, you must push your feet against the ground to make yourself move forward. When the sidewalk is dry, the stone or concrete is rough and your shoes do not slip. You slip on ice because the surface of the ice is smooth and your shoes slide over it very easily.

When two things rub against each other, we say that there is *friction*. Rough things make much friction when they rub against each other. Smooth things make little friction. Wax on floors makes them so smooth that there is little friction between your shoes and the floor, and you slide easily. If you want things to slide easily over each other, make their surfaces as smooth as possible.

Does this tell you anything about machines? Machines have parts that move. These moving parts rub against each other. When you raise a weight with a lever, the lever bar rubs against the fulcrum. When a wheel turns on an axle, the axle and part of the wheel rub against each other. Machines like engines, watches, and sewing-machines have many parts that rub against each other. Whenever a machine is moving, there is friction between the moving parts. When many parts of a machine rub against each other, it takes more force to move them. Friction keeps the parts from moving easily.

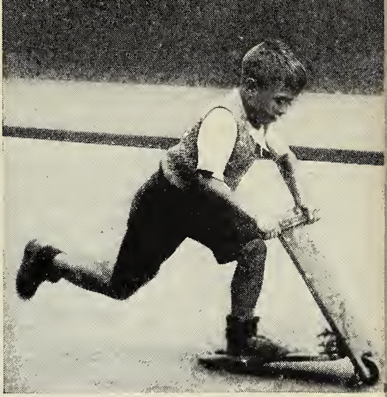
To make the parts move easily, we must make the parts as smooth as possible. When oil is put on parts that rub together, the oil makes a very smooth surface. You can see that this is true if you try an experiment. Rub two flat pieces of iron together. Now put some oil or grease on the surfaces of the iron pieces and rub them together. Can you see how much easier they slide over each other? This shows you one reason for putting oil and grease in machines. Oil and grease help the parts slide over each other more easily.

Of course you know that when two materials rub together they wear out. The rougher they are, the faster they wear out. The soles of your shoes wear out as they rub on the sidewalk. Our machines wear out, too. But they will last longer if we put oil or grease between the moving parts.

Oil and grease do another valuable thing, too. Rub the palms of your hands together very rapidly. Do they soon feel hot? Try rubbing a penny as rapidly as you can on your sleeve. You can make it so hot that it will be hard to hold. When two metal surfaces rub against each other in an engine, they get very hot. But when oil is put on them, they do not get so hot because they slide over each other more easily.

Did you ever hear anyone say that he had "burned out" his automobile engine? Something had happened to keep the oil from getting to the moving parts of the engine. The parts had become so hot that they were ruined. Some parts of the automobile engine will melt if there is no oil to keep the parts from rubbing together too hard.

If you want your bicycle or roller-skates to work well, you must be sure to keep them oiled. You put oil or grease on the parts that rub against each other as they move. Probably your mother keeps an oil-can in the house. She uses it for the sewing-machine, the vacuum-cleaner, the washing-machine, and for other household machines.



Is there a wheel under the back of this scooter? Why do you think so?

Now you can see another reason why we use wheels. Suppose you try to drag a heavy box over the ground. The bottom of the box and the ground are rubbing against each other. It takes a large amount of force to move the box because so much of the bottom is rubbing against the ground.

Now suppose you put wheels under the box. This raises the box up off the ground. Only a small part of each wheel touches the ground. Of course, each wheel rubs against its small axle, but the surfaces that rub against each other are much smaller than the whole bottom of the box and the ground. So the box can be moved much more easily.

Try this experiment to discover another easy way of moving heavy loads. Get a box and put some stones in it. Slide it along on the floor. Now put some shot or *ball-bearings* on the floor. Put the box on the ball-bearings and push it. Does it move more easily? Ball-bearings are like little wheels. They are called ball-bearings because they are little balls that the moving parts of machines bear down on, or press against. They help to keep the moving parts of a machine from rubbing together; so a machine with ball-bearings in it takes less force to run. Ball-bearings need oil, too, because they are rubbing against each other and against other parts of the machine.

* * *

1. Why do automobiles skid on wet or icy pavements?

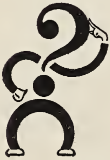
2. Would you rather have a pair of roller-skates with ball-bearings in them or a pair without ball-bearings? Why?

3. Why do heavy pianos and other pieces of furniture often have small wheels called *rollers* or *casters* under them?

4. Cars on railroad trains often get "hot boxes" in the wheels. What do you think causes this?

5. Why does a gardener put oil in different parts of a lawn-mower?

Questions to Answer



1. How do you think the world would be different if we had no machines?

2. Where have you seen machines being used while you have been studying about them in this book?

3. How are fixed pulleys different from movable pulleys?

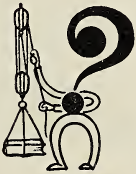
4. Which kind of simple machine is used to: split wood, cut cloth, pull nails, plow snow from the side-

walk, get a heavy barrel into a truck, lift an automobile to change tires, make it easy to open and close windows.

5. How many different kinds of machines can you find in your school-house? Tell what they are used for.

6. What part of a wheel and axle needs to be greased or oiled?

Things to Find Out



1. Examine some of the machines in your home and try to find out how they work.

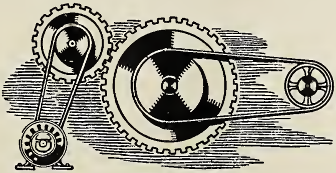
2. Make a list of uses for each of these machines: a pulley, a lever, a wheel and axle, an inclined plane, a screw.

3. Find pictures that show how machines are used to do different kinds of work.

4. Have someone in your class bring his mechanical building set to school. Build simple machines and find out how they work.

5. Make a collection of all the kinds of tools you can find that are simple machines. Show what kinds of simple machines they are.

6. Bring some of your toys to school. Examine them to see how many simple machines are found in each toy.



UNIT THREE

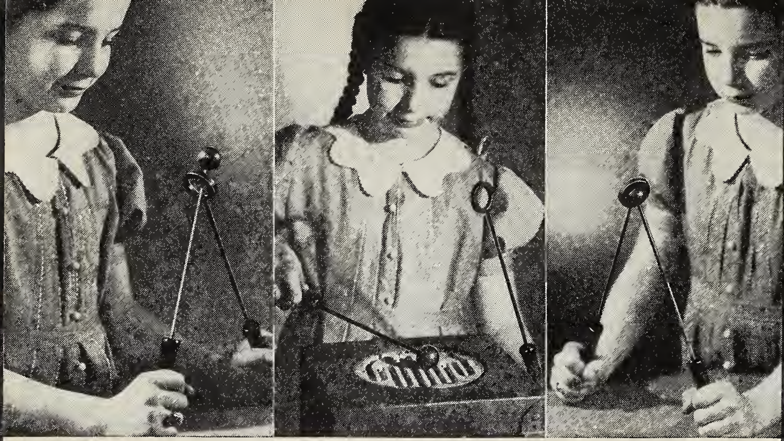
HOW DOES HEAT CHANGE MATERIALS?

Jack's mother was getting supper. When she had almost finished, she asked Jack to get a jar of fruit from the basement. Then she asked him to open it. It was a glass jar with a metal top that screwed on. But Jack could not unscrew the top, no matter how hard he tried. When his mother saw the trouble he was having, she said, "Pour a little water in a pan and put the pan on the stove. Stand the jar upside down in the water until the water is hot. Then try to unscrew the top."

Jack did as his mother said. To his surprise, the top unscrewed easily. "Why did hot water make it easy to get the top off?" asked Jack.

How does heat change the size of solid materials?

Do you know why the top of the jar came off so easily when it was heated by the hot water? Suppose you try an experiment to find out. Stretch a piece of copper or iron wire about three feet long between two supports on a table. Stretch the wire as tight as you can. Hang a small stone or weight from the center of the wire so that the weight almost



touches the table. Heat the wire along its whole length. What did heat do to the wire?

Now try another experiment. Get a screw eye and a ball-bearing that will just go through the hole in the screw eye. Heat the ball until it is quite hot. Will it go through the hole? What do you think happened to it?

Get a bolt and a nut that just fits it. Take the nut off and heat the bolt red hot. Then try to put the nut on. What has happened? Is the bolt too large now for the nut to go on?

Do you think you know now why the hot top of the jar unscrewed so easily? You may wish to try another experiment to be sure you are right. Get a strip of tin or other metal and nail both ends down flat on a board. Then hold the metal strip over the heat and watch the strip. How do you know that the heat is making it longer?

You saw that the wire and the strip of metal became longer when you heated them. They became thicker, too. The bolt and the ball, also, got bigger when you heated them. We say that these things *expanded* when they were heated. This is another way of saying that they got larger, or took up more room.

If you tried many different kinds of solids, you would find that most of them expand or get larger when they are heated. Now do you see why Jack could unscrew the hot top of the jar? The hot water made the metal top hot. The heat expanded the top. It got larger; so it was not tight on the jar. Then the jar could be opened easily.

After all these solids have cooled, suppose you look at them. Did the wire get tight again? How do you know? Will the nut now fit on the bolt? What happened to the ball when it cooled? Will it go through the hole in the screw eye? The wire got shorter when it cooled. The ball got smaller when it cooled. We say that they *contracted.* "Contract" means to get smaller. Most solids contract, or get smaller, when they cool.

On a very hot summer day James and his parents were waiting to cross a long iron bridge. The bridge had opened to let a boat pass up the river. While they were waiting, James's father said, "This bridge is several inches longer now than it was last

If Mrs. Brown screws cold tops on to hot jars, will the jars stay sealed tightly?

winter when we crossed it." A little later, as they drove along a country road, James's father said, "See how those telephone wires sag. They are longer now than they were last winter." Did James's father really mean what he said, or was he joking?

Suppose workers on a telephone line were stringing wires between poles on a hot summer day. Do you think they should stretch the wires tightly, or should they let the wires sag? If these wires were stretched tightly, what would happen to them as soon as the weather became cold?

Men who build iron bridges know that the bridges will get longer when the hot summer days come. They build the bridges so that there will be room for them to expand. Sometimes one end of a bridge rests on rollers. When heat expands the metal in the bridge, the end of the bridge can move. Iron bridges are not always placed on rollers, but there is always room left for them to expand when they are heated by the sun. What might happen if they could not expand?

Try to find out how steel rails are put together in a railroad track. Do the ends of the rails fit tightly against each other? Why do the men who lay them leave a space between the ends of the rails? They leave a small space between one rail and the next rail, so that when the hot sun shines down on the rails there will be room for them to get longer. In the winter they will get shorter.

Have you ever ridden along a concrete road in summer and felt your car go bump, bump, bump as you drove along? Do you know why you felt these bumps? Concrete roads are not made in one long strip that goes on for miles. Instead, they are usually made in short blocks. Between these blocks the road-builders leave a small space. Do you know why? Often this space between blocks is filled with tar. You know, of course, that heat makes the tar expand. It also makes the concrete

The thousands of parts in this big bridge are put together so that the materials can expand and contract.

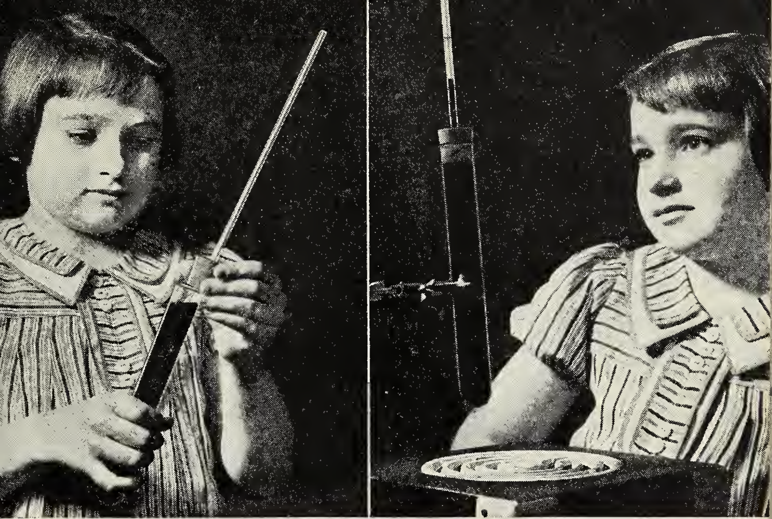
expand and squeeze the tar. So the tar bulges up through the cracks. When the wheels of the car travel along the road over these strips of tar, you feel the bumps.

* * *

1. Why is it important for men to know that heating changes the size of solids?
2. What does *contract* mean?
3. What does *expand* mean?
4. Make one sentence that will tell the important idea you have learned in the last few pages.
5. Windows on fire-escapes usually are made with iron frames. Will the windows fit as tightly in winter as in summer? Explain.

What happens to liquids when they are heated?

WHEN JOHN was studying science, he was always thinking up experiments to do at home. One time he decided to find out what the temperature of water is when it boils. He found a thermometer that his mother said he could have, and he put a pan of water on the stove. While the water was still cool, he set the thermometer in it. As the water slowly heated, the red liquid in the thermometer went up and up. At last it reached the top of the



thermometer. Suddenly the glass broke, and the red liquid ran out into the water.

What made the thermometer burst? Here is an experiment that will help you to find out. You will need a test-tube and a rubber stopper with a hole in it. Use a stopper that just fits into the tube. Get a piece of glass tubing about a foot long that will fit into the hole in the stopper.

Fill the test-tube with colored water. You can use red ink to color the water. Fit the glass tubing into the stopper and then put the stopper into the test-tube. Push the stopper down tight so that some of the water rises in the tube. Now heat the water slowly and watch carefully to see what happens. The red color makes it easy for you to see

UNIVERSITY OF ALBERTA

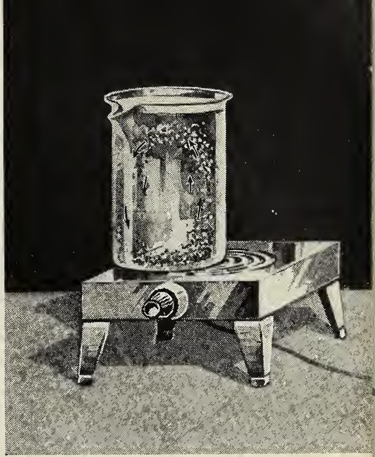
the water. Why does the water go up higher into the glass tubing?

You can see that when the water is warmed, it expands, or takes up more room, just as iron and other solids do. As the water expands, it goes up into the tube. Now cool the test-tube and watch the liquid. Why does it go down in the tube? When liquids are cooled, they get smaller, or contract. Liquids expand when they are heated and contract when they are cooled.

You know now why John's thermometer broke. The liquid in the thermometer got very hot. It expanded until it took up all the room in the glass. Then it kept expanding until it broke the glass and ran out. Hold your finger on the bulb of the thermometer in your school-room. Why does the liquid rise in the tube?

If you fill your tea-kettle to the top with cold water and then heat the water, what will happen? Why? Can you use what you have learned to explain what happened when Mrs. Brown canned some tomato juice? She boiled the juice and filled some glass jars full with the hot juice. Then she sealed the jars and put them away in the cool basement. She opened one of the jars a few weeks later and found that it was no longer full to the top. Do you know why? You might ask your mother if she has ever had this experience.

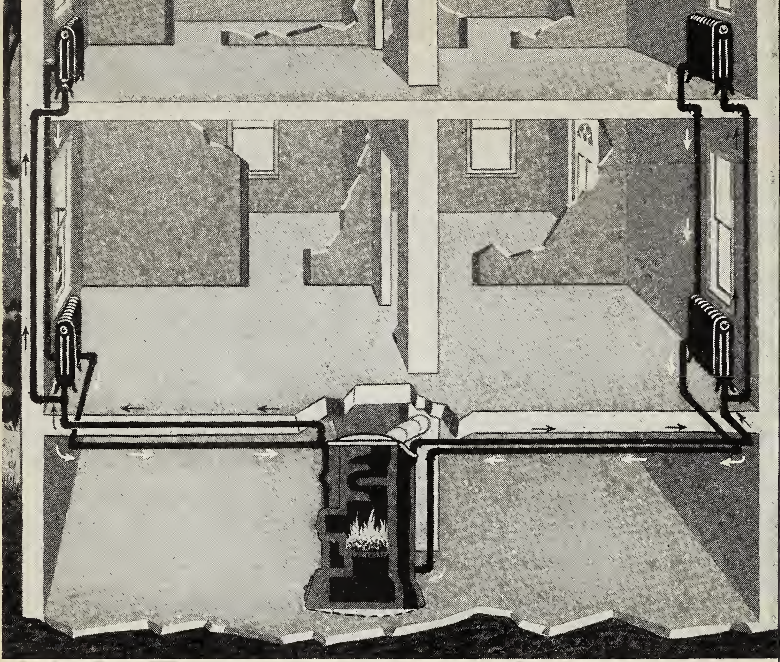
You have learned that heat makes liquids expand. Heat does something else to liquids. Here is an experiment that will help you to understand what it is.



How is the water at the top different from the water at the bottom? Explain why the water is moving.

Fill a large beaker with water and put some coarse wet sawdust in the water. The sawdust will sink to the bottom because it is wet. Now heat part of the bottom of the beaker and watch the sawdust. Why does the sawdust move up from the bottom of the beaker on one side and then down the other side and then up again?

Water carries the sawdust. The water at one side of the bottom of the beaker is getting hot. You know that it is expanding. It is also getting lighter. The water at the top is cooler than the water at the bottom. It is also heavier than the warmer water. It sinks to the bottom along one side and pushes the lighter hot water up. Do you see that heating makes water move? The heavy, colder water sinks and pushes the lighter, warmer water up.



Now that you know what heat does to water, you can perhaps understand how hot water is used to heat a house. Study the picture of a hot-water furnace on this page. This furnace is just a big boiler that heats water. There are two walls of iron around the furnace. Between these walls there is water. The space filled with water is called a *water-jacket*. Pipes run from the top of the water-jacket up through the house. In the rooms are big iron radiators. The pipes connect the furnace with the radiators. Look at the picture again. Do you see that a pipe runs from each radiator back down to the furnace? Does this pipe go into the water-jacket at the top or at the bottom?

When there is fire in the furnace, the water in the water-jacket gets hot. The water expands and gets lighter. Upstairs the water in the radiators and pipes is cool. This heavy cool water begins to push down through the pipes to the furnace. It pushes the lighter hot water up through the pipes and radiators. They get warm and heat the rooms. As the water in the radiators gets cool, it contracts and gets heavier. The pipes take it back to the furnace where it is heated again. Then it begins another trip through the pipes to heat the rooms.

Perhaps your home is heated by hot water. If it is, find out where the pipes are that carry the water. Find the place where the pipes go into the furnace. Where do they come out? Try to see how the pipes go to each radiator. Look carefully at your furnace and try to find out how it works.

1. Why does the colored liquid go up and down in a thermometer?

2. Why does water move through the pipes in a hot-water heating system?

3. If a fountain-pen is filled with ink, it will sometimes leak on a very hot day. Why?

How does heat change gases?

The Bates family had just bought a new house. One afternoon Mary's father said, "Let's go over and see our new house. I have just built a fire in the furnace."

By the time they got to the house, Mary was a little cold. As soon as they were inside, she went over to a register at one side of the room. "I thought you said there was a fire in the furnace," she said. "There isn't any heat coming up."

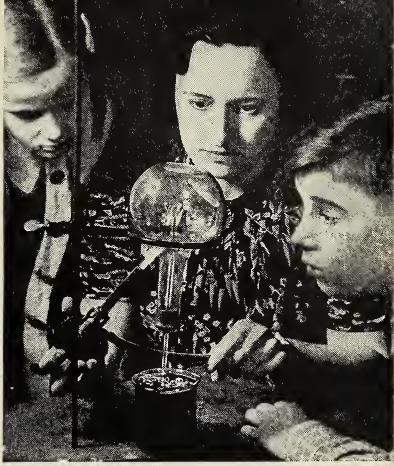
"Of course not," replied her father. "That is a cold-air register. Over here is the place where the warm air comes up from the furnace."

After awhile they all went down to look at the basement. Here Mary's father showed her the big pipe that brought cold air into the bottom of the furnace. She also saw the pipes that carried warm air up into the rooms. These pipes came out of the top of the furnace. Her father explained how the air traveled through the house to make the rooms warm.

Do you know how the warm air and the cold air travel in your home and in your school-room? Do you know how warm air is different from cold air? Suppose you do a few experiments to help you find the answers to these questions.

What happens to air when it is heated? For the first experiment find a bottle that has a small mouth. A medicine bottle will do. Set the bottle out-of-doors or in some place where it will get cold. Then fill a drinking-glass with water.

When the bottle is cold, put its mouth straight down into the water in the drinking-glass. Hold both of your hands around the bottle so that the heat from them will warm the bottle and the air inside the bottle. Do you see anything come out of the bottle? If nothing happens, you are probably not making the air warm enough. In that case try heating the bottle very gently, or pour some warm water on it. Be sure to keep the mouth of the bottle under the water. What do you see? What are the bubbles? Why do they come out of the bottle?



Explain what is happening in this picture. What is causing the bubbles on top of the water in the beaker?

The bubbles are air. The bottle was full of air before it was heated. When this air was warmed, it expanded and needed more room; so it came out into the water and bubbled to the top.

Try another experiment. Stretch the neck of a toy rubber balloon over the mouth of a bottle.

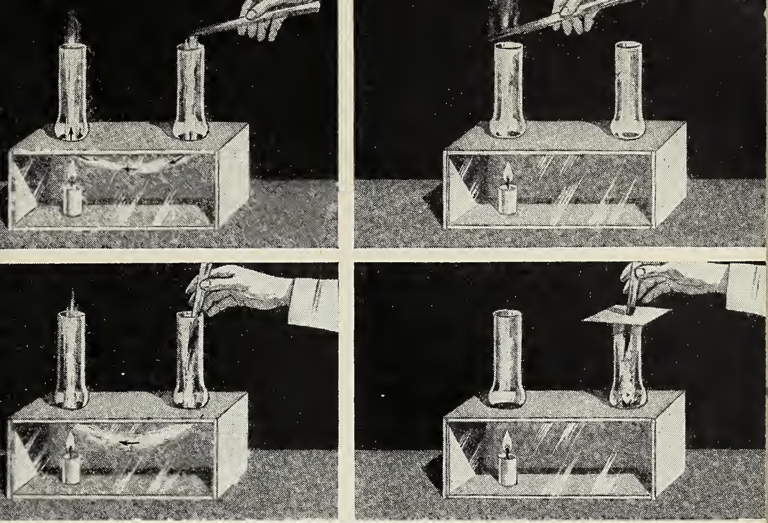
Heat the bottle. Why does the balloon begin to puff out? The air expands when it is heated. All gases expand when they are heated.

Now think again about the furnace in Mary's new home. The air in the furnace was heated by the fire. The heat made the air expand. Then it went into the pipes at the top of the furnace and up to the rooms of the house. Does warm air always go up? Try these experiments.

For your first experiment get two thermometers. Hang one up near the ceiling of your school-room and place the other near the floor. Where is the air warmer?

For the next experiment, find a wooden box like the one in the picture on page 117. A box about twice as large as a chalk box will work well. You will also need two lamp chimneys.

Cut two holes in the top of the box and place a lamp chimney over each hole. Put a small candle in the box under one of the chimneys. Light the candle and cover the open side of the box with a piece of glass. Now cut a small splinter of wood from a chalk box. Light the splinter and let it start to burn, and then blow out the flame. While the splinter is still smoking, hold it over the lamp chimney that does not have the candle under it. Where does the smoke go? Now hold the smoking splinter over the other chimney. Where does the



smoke go this time? If you see the smoke moving, you know which way the air is moving, for the smoke is being carried by moving air.

Light the splinter again and blow it out. This time place the smoking splinter farther down inside the chimney that does not have the candle under it. What is happening to the smoke in the box?

Now put a splinter through a piece of cardboard big enough to cover the chimney. Make the splinter smoke and put it down in the chimney that has no candle under it. Hold the cardboard tightly against the top of the chimney. What happens to the smoke now? What has stopped it from moving?

Answer the questions at the top of the next page, and you will understand what has happened.

UNIVERSITY OF ALBERTA

How did the heat from the candle change the air around the candle?

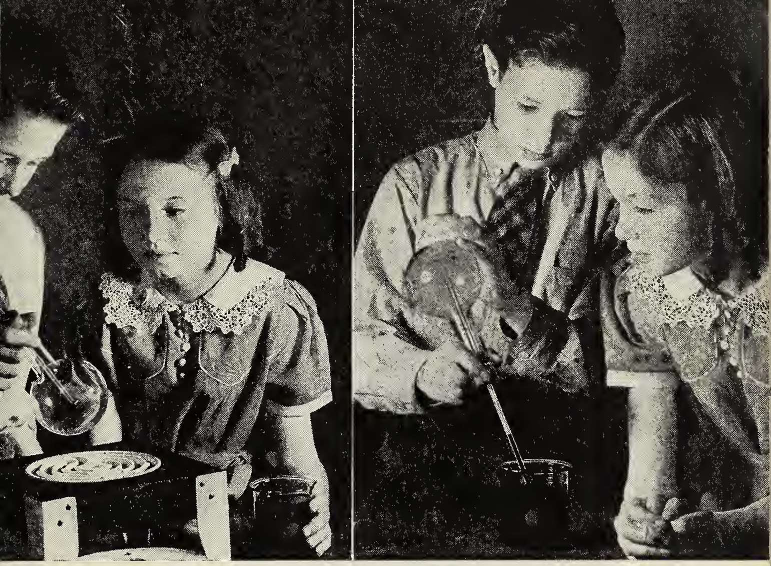
Which way did the air move in the warm-air chimney?

Which way did it move in the cold-air chimney?

Now can you tell why the air travels down the cold chimney and up the warm chimney? To understand why, we must do another experiment. Get a basketball or a volley-ball and a pair of scales. Also get a bicycle pump. Let all the air out of the ball and put it on the scales. Put weights on the other side of the scales until the scales balance exactly. Now take the ball off and pump it up hard. Put it back on the scales. Is it heavier? Does air really weigh something?

Probably you have never thought that air has weight. But when you filled the ball with air, it was heavier than when it was empty. All materials have weight, and air is a material.

Now think about the experiment with the box and the chimneys. The warm air went up, and the cold air came down. Can you tell why the cold air came down? This is the reason: Cold air is heavier than the same amount of warm air. You know that any heavy material presses down hard. The air in the cold chimney is heavier than the air in the warm chimney; so it sinks down into the box. This cold air sinking down into the box

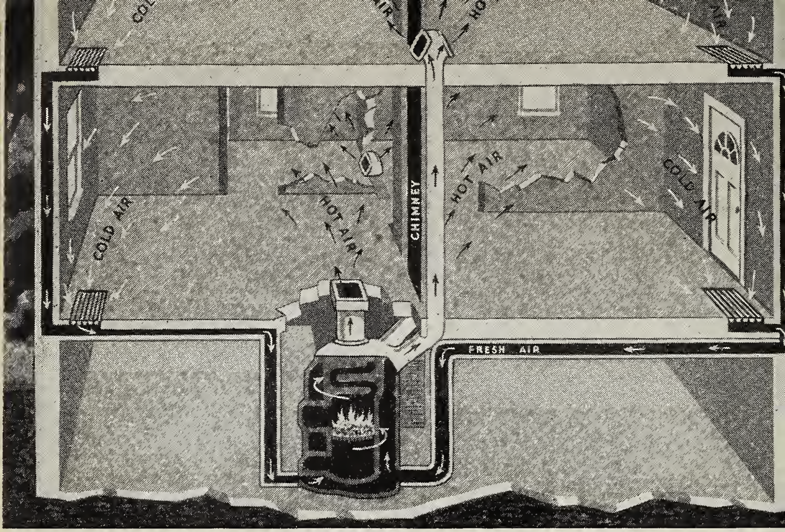


pushes the lighter warm air up out of the warm chimney. When you covered the chimney with cardboard, you kept cold air from getting in and sinking into the box. The smoke did not move.

There is another difference between warm air and cold air. Put the mouth of a bottle under water and warm the bottle. When it is as warm as you can make it, cool it with a piece of ice. Be sure to keep the mouth of the bottle under the water. What happens? Why does the water go up into the bottle? If you can get a one-hole stopper and a flask, as shown in these pictures, you can see more easily what happens in the experiment.

When the air inside the bottle was cooled, it did

UNIVERSITY OF ALBERTA



not take up as much room as it did when it was warm. As it cooled, it got smaller and smaller, and some of the water came up into the bottle to take up the room that was left as the air became smaller. Air contracts when it is cooled. All gases contract when they are cooled.

Now, have your experiments helped you understand how the warm air and the cold air moved in Mary's house? The cold air was heavy; so it sank down the pipe to the bottom of the furnace. There it was warmed by the fire in the furnace. The heat made this air expand and get lighter. The heavy cold air pushed the warm air up through the pipes into the rooms. In the rooms it rose to the ceiling. Then the air began to get cool and heavier.

It sank down through the cold-air register and the pipe to the bottom of the furnace.

Can you use what you have found out in your experiments to explain what happened to John and his father? One hot summer day they were riding in their car. The pavement was very hot. Suddenly there was a loud bang. The car swayed from side to side, and John's father had a hard time keeping it on the road. One of the tires on the car had blown out.

"I told Henry not to put too much air in that tire," said John's father. "It's an old tire."

Why was it not safe to put so much air in that old tire on a hot day?

* * *

1. Each sentence below has a blank in it. Choose a word to take the place of the blank so that the sentence will tell an important fact about what heating or cooling does to gases.

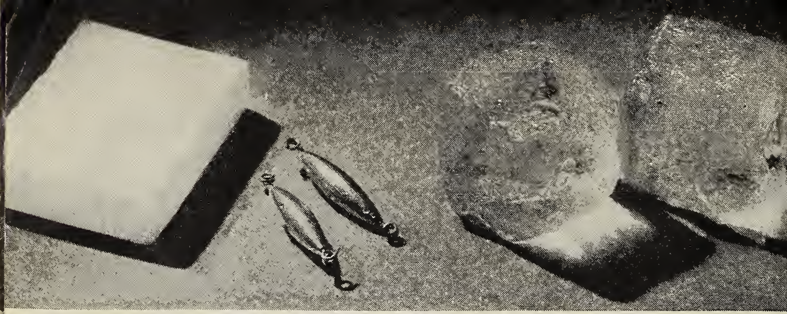
a) Gases ____ when they are heated.

b) Hot air rises because it is ____ than the air around it.

c) Gases ____ when they are cooled.

d) The air in a room is usually ____ near the ceiling.

2. If a football is pumped up in a warm room and then taken out-of-doors on a cold day, will it get harder or softer? Why?



Which of these will melt first—the paraffin, the lead, or the ice?

How much heat does it take to change solids to liquids?

SUPPOSE you try this experiment: Take an iron pan and put in it a piece of hard butter, a piece of paraffin, a piece of lead, and a piece of aluminum. Put the pan over some heat. Which material melts first? The butter and the paraffin melt first. Then the lead melts. Did the aluminum melt? You could not get the pan hot enough to melt the aluminum or the iron of the pan, but you know that fires can be made so hot that iron and aluminum will melt in them.

Many solids change to liquids when they get hot, but each kind of solid needs a different amount of heat to make it melt. The temperature at which a solid melts is called the *melting-point* of that solid. What is the melting-point of ice?

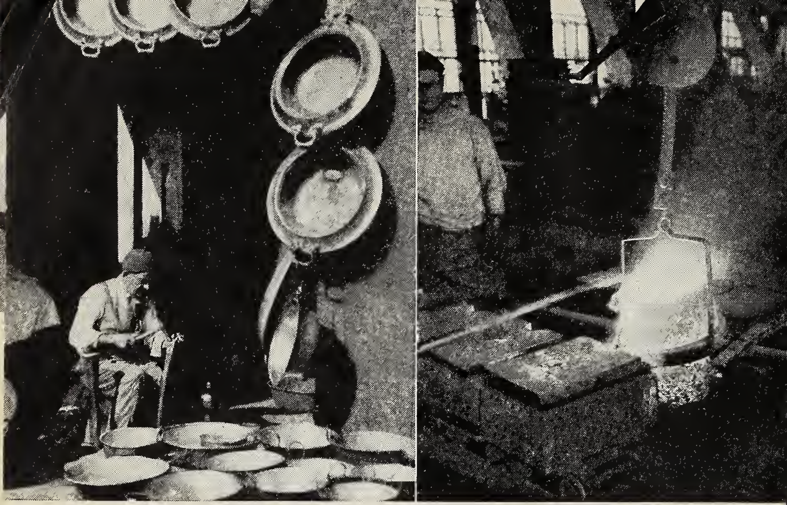
You can find out if you try this experiment. Put a thermometer into a pan of melting ice cubes.

Read the thermometer several times until the ice has all melted. Did you find that the melting-point of ice is 32 degrees? When the temperature of ice gets to 32 degrees, the ice changes to water.

Lead must be heated to 620 degrees before it will change to liquid. Gold must be heated to about 2000 degrees before it will melt, and the big furnaces where iron is melted get to a temperature of over 2700 degrees before the iron in them will melt. There are even some kinds of rock that will change to liquid if they get hot enough. You know that volcanoes sometimes pour out melted rock.

Scientists have spent years and years experimenting to find how to melt metals. They had to learn how to make very hot fires. The Indians found copper long before the white man came, but they did not make much use of it. They could only hammer it into shape with stones. They did not know how to melt it; so they could not pour it into molds to make things of different shapes. Many of the iron things we use are made by melting iron and pouring the liquid iron into molds.

We could not mix metals, either, if we did not know how to melt them. You have often seen pieces of brass. It is a bright yellow metal, that is made by melting and mixing copper and zinc. It is harder than either copper or zinc; so we find many uses for it in our machinery. For some uses it is



One way to use metal is to pound it into objects like the utensils at the left. Compare this way with that shown at the right, where white-hot, melted metal is being poured into covered molds.

better than iron and steel because it will not rust. Bronze, also, is made by melting and mixing two metals, copper and tin. Bronze will not rust, and it is harder than either copper or tin.

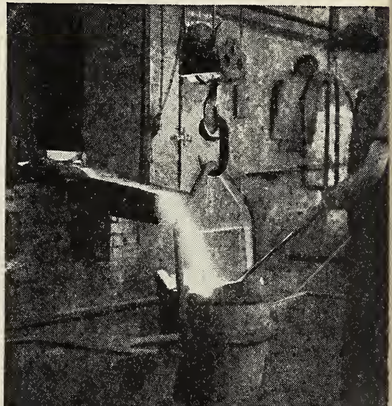
* * *

1. What do we mean by the melting-point of a solid material?
2. Why do men often want to melt solid materials?
3. Why would lead not be good for making cooking pans or skillets?
4. Why do men sometimes want to mix metals?

How much heat does it take to change liquids to gases?

IN WINTER does your father put alcohol in the radiator of the automobile to keep the water from freezing? Perhaps you have heard him say, "My radiator boiled yesterday, and I suppose the alcohol is all gone. I'll have to get some more." Do you know why the alcohol changed to a gas before the water did? If you could boil some alcohol, you would understand why the alcohol changed to a gas and left the water behind. If you put a thermometer in water when it boils, it will read 212 degrees. Alcohol boils at 172 degrees.

No matter how fast you boil a liquid, it will not get any hotter than it was when it first began to boil. When it boils, it is changing from a liquid to a gas just as fast as it can. The temperature at which a liquid boils is its *boiling-point.* The boiling-point of water is 212 degrees. The boiling-point of alcohol is 172 degrees. The boiling-point of mercury is 675 degrees! Every liquid has its own boiling-point.



Which is hotter, boiling water or the melted iron coming out of this furnace? How do you know?

UNIVERSITY OF ALBERTA

When the automobile engine runs, the alcohol and water in the radiator both get warm. They may get as hot as 172 degrees. Then the alcohol will boil and change to a gas quickly. Is this temperature high enough to boil the water? Some of the water will change to a gas, but it will not change very fast until it boils. It will not boil until it reaches 212 degrees. So the water stays in the radiator long after all the alcohol has gone into the air.

In many science books you may see the boiling-point of water written 212° F. That means 212° on a Fahrenheit thermometer. A scientist named Fahrenheit figured out just where to put the marks for the degrees on this kind of thermometer.

But of course you know that you do not have to boil a liquid to make it change to a gas. Water is always changing to a gas, or *evaporating*. Water evaporates all the time from lakes, from moist soil, and from wet pavements. Gasoline and alcohol also evaporate if they are left in an open container. These experiments show more about how different liquids evaporate.

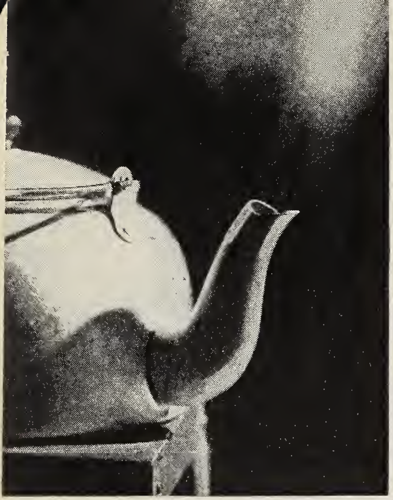
Take two pans that are just alike and put exactly one pint of water in each pan. Mark each pan to show just how high the water comes. Heat one of the pans slowly. Do not heat the other one. After a half hour examine the pans. Did heat make the water evaporate faster in one of them? Why is it

What becomes of the water in these clothes? What difference does warm sunshine make in drying them?

important to have the same amount of water in the two pans before you begin to heat one of them?

Now get two saucers or shallow pans that are exactly alike in shape and size. Put alcohol in one and water in the other. Let them stand for a number of hours and see which liquid evaporates more rapidly. Did your experiment seem to show that some liquids evaporate more rapidly than others? Scientists know that some liquids evaporate more rapidly than others. Heat makes any liquid evaporate more rapidly.

UNIVERSITY OF ALBERTA



Water that has evaporated into the air can be changed back to a liquid again. Do you know how? Here is a picture of a tea-kettle full of boiling water. Look carefully at the picture. Can you see anything close to the spout of the kettle? This place that looks empty is really filled with steam. You cannot see it, because it is a colorless gas. Steam is very, very hot.

As the steam, or *water vapor*, gets farther away from the hot kettle, it changes into very tiny drops of water again. These tiny drops make the cloud that comes out of the tea-kettle. If you hold a cold pie-plate in this cloud, you will find that the plate will soon be covered with water. How does this water get on the plate?

The steam changes to liquid water because the steam is cooled. The air around the tea-kettle is cool enough to change the steam back into tiny drops of water. The cold pie-plate catches these drops of water. We say that the water vapor *condenses*. If you blow your breath against a cold window-pane, the water vapor that is in your breath changes from a gas to a liquid when it strikes the cold glass. Cooling helps gases condense, or change into liquids. Heat helps liquids evaporate, or change into gases.

* * * *

1. Why can you "see your breath" on a very cold day, but cannot see it on a warm day?

2. Does it take the same amount of heat to boil all liquids? Give an example to prove your answer.

3. What does the word *evaporate* mean?

4. What does the word *condense* mean?

5. When it rains, is water vapor condensing or is water evaporating?

6. Have you ever seen steam? Explain your answer.

7. Will a hot fire make boiling water any hotter than 212° F.? How could your mother save gas by knowing this?

Questions to Answer

1. If very hot water is poured into a thick drinking glass, the glass will usually break. Why does this happen? What does this tell you about washing dishes?

2. Baking-powder is often mixed in the flour to make biscuits or cake. When the dough is heated, the baking-powder forms carbon-dioxide gas. The gas is trapped in the dough. As the dough is heated, it gets larger. Why?

UNIVERSITY OF ALBERTA

3. Why does the ceiling above a radiator or register get dirtier than the rest of the ceiling?

4. Why do smoke and steam usually go up instead of down?

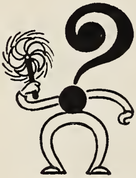
5. In an ice-box why is the ice kept at the top or the side instead of at the bottom?

6. If you want to get fresh air into a room, why is it best to open the window at both the top and the bottom?

7. Wagon wheels usually have iron rims or tires. Before these tires are put on the wooden wheels, they are first heated very hot. Then they are slipped over the wheels. Why are the tires heated before they are put on?

8. Sometimes we keep materials in bottles with glass stoppers. These stoppers often are hard to remove. How could you use what you have learned about heat to help you remove a glass stopper that was stuck tight?

Things to Find Out



1. Find out what "dry ice" is. Probably your druggist can tell you. Make a report to the class.

2. Find out one reason why rivets are heated red-hot when they are put into steel beams to hold the beams together.

3. Make a list of some things at home and at school that have been made by changing a solid to a liquid and then letting the liquid cool.

4. When water freezes, does it expand or contract? Think out an experiment to prove your answer. Find

out whether water is different from other liquids in the way it acts when it freezes.

5. If you can find a can of automobile anti-freeze mixture, read the directions on it. Explain to the class everything you can about the directions.

6. Make a drawing of a room with a stove at one side. Show by arrows the direction of the air currents in the room.

7. Make a pinwheel of paper. Hold it over a register, or stove, or radiator. Why does it turn?

UNIVERSITY OF ALBERTA

UNIT FOUR

WHY DOES THE WEATHER CHANGE?

Do you know what the Indians in the picture are doing? They are dancing a rain dance! There has been no rain in their land for many months. Their crops of corn and other food plants are drying up, and their animals are dying of thirst. They believe that they can make rain come by doing this strange dance.

People have often wished that they could change the weather, but no one has ever been able to do so. We cannot change the weather, but scientists have found out many things about weather. They know why it rains and snows, and why the wind blows. They know why the weather changes. They can tell us when it is going to change, so that we can make our plans fit the weather.

Do you know what makes rain and snow? Do you know what makes the wind blow, and why it sometimes blows in one direction and then in another? What are clouds? Have you ever wondered how the "weather man" can tell what kind of weather is coming? This unit will help you to answer these questions.

UNIVERSITY OF ALBERTA

How would you describe the weather in each of these pictures?

What is weather?

If someone called you on the telephone and asked you about the weather where you live, what would you say? You would look out-of-doors and perhaps say, "It is very cloudy and cold. The wind is blowing from the northwest. The weather has changed since morning. This morning the sun was shining, and there were only a few clouds in the sky." Or you might say, "It is a very hot day. There is hardly any breeze, and there is not a cloud in the sky."

Suppose you appoint a committee of your class members to clip weather reports from the newspaper. Have another committee listen to weather reports over the radio. Then make a list of all the words used to describe the weather. Write the words on the blackboard. Put a check after the words that tell what kind of weather it is today. How many of the words tell something about the air?

Your list shows you that there are several different things to think about before you can describe the weather. You must look at the sky to see if it is cloudy or clear. You must notice whether the wind is strong or gentle and in what direction it is blowing. If it is blowing from the south, you say that it is a south wind. If it blows from the north, it is a north wind. You must also find whether the temperature is hot, cold, or mild. Then you put all these observations together and decide what you will say about the weather.

But what you say about the weather now may not be true three or four hours later! Sometimes we say that a person is "as changeable as the weather." We mean that you never can tell what the person will do, because he may change his mind any minute. The weather changes, too. It may change many times in one week, or even change several times in one day.

Keep a record of the weather for several weeks

UNIVERSITY OF ALBERTA

and see how many changes there are. You may find that dry weather changes to wet weather, and that the wet weather changes again to dry weather. Hot days will follow cool days, and then there will be hot days again.

For your record make a big chart on the blackboard, like the one below. You may also want to keep a separate record of the temperature as it changes during each day. For this record, take the temperature three times a day: in the morning, at noon, and at sundown.

WEATHER CHART

Date	Temperature	Feeling of Air	Sky	Direction of Wind	Rain or Snow
Feb. 10	34 degrees	Damp	Cloudy	Southwest	None
Feb. 11	28 degrees	Dry	Clear	No Wind	None

Now let us see why the weather changes. You know that the earth is a ball of soil and rock, with much of its surface covered by water. You also know that there is a layer of air all around the earth. No one knows how far up this air goes. Scientists think that the layer of air may be anywhere from 50

In foggy weather like that in the first picture the air is damp and cold. How is this air different from the air in the second picture?

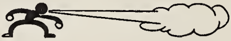
to 200 miles thick. Does the air have anything to do with weather? Look at your list of words that describe weather. Do most of them describe the air, too? If you use such words as hot, cold, damp, and windy, what is it that is hot, cold, damp, or windy? It is the air.

Weather is the condition of the air around us at any time. Sometimes the air is hot; sometimes it is cold. Sometimes the air is dry, while at other times it is wet. When the air is dry, the sky is usually clear. When the air is wet, the sky is usually cloudy.

All of these changes that take place in the air make our different kinds of weather. When scien-

UNIVERSITY OF ALBERTA

tists study weather, they are studying how the air changes. Before you can understand why the weather changes, you need to know many things about why and how the air changes.



1. How would you describe the weather today?
2. What changes have there been in the weather since a week ago?
3. If the air never changed, would the weather change? Prove that you are right by reading sentences from this book or from other books.
4. Why do you need to know about air before you can understand weather?

Why does the temperature change?

"I WISH it would get a little cooler," said Mr. Smith, as he was working in his garden in the hot sun.

"The morning paper said, 'Cooler tomorrow,'" replied his neighbor. "And I think it will be cooler because the wind is changing from south to north."

If you keep a record of the temperature for one week, you will be surprised to find how much it changes. Even in one day it may change more than twenty degrees. Why does it change? To answer that question, we must first know a few things about how the sun warms the earth and the air. This experiment will help you find out.

Get two small fruit jars and paint one of them black. Fill both jars with water. Take the temperature of the water to be sure that it is just as warm in one jar as in the other. Then set the two jars in the sunlight. After a half hour, take the temperature of the water in each jar again. Which is warmer?

When the sun's rays pass through a transparent material like air or clear glass, they heat the material only a little. But when the rays strike a material that they cannot pass through, they usually heat it much more. The rays could not pass through the blackened glass of the jar in your experiment. So the glass in that jar became warmer than the clear glass in the other jar. The warm glass made the water warm.

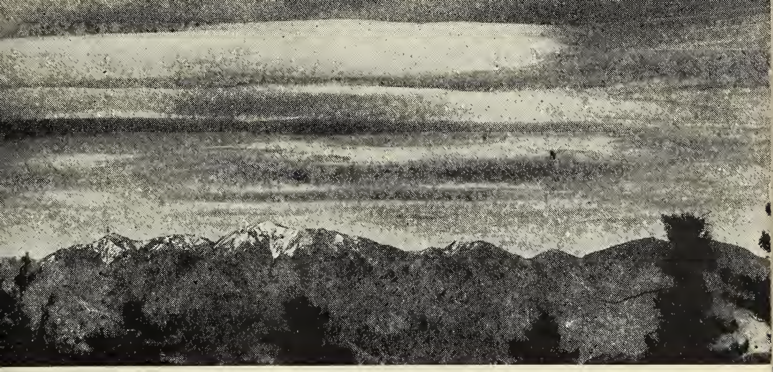
You know that on a hot day the sidewalk and the pavement are much hotter than the air. In summer the transparent glass in the window-pane is much cooler than the floor on which the sun has been shining.

Do you know how the sun heats the air? The sun's rays pass through the air, but they heat it only a little. When the rays strike the earth, they heat the soil, rocks, and water much hotter than they heat the air. Then the warm soil, the warm rocks, and the warm water give off some of their heat to the air.

Most of our cold winds come from the north. It is so cold in the Far North that the ice houses of the Eskimos will stand all winter without melting.

You can see now that the air will be warmer in one place than in another. It is warmest over the places where the earth is heated most. In the daytime the air over land is hotter than the air over water because the sun does not warm the water as much as it warms land. But land cools off faster than water does; so when the sun goes down, the air over water is often warmer than the air over land along the shore. The air above a forest is often cooler than the air above the earth near the forest.

There is another thing you need to know to help you understand changes in weather. Some parts of the world are always hotter than other parts. And some parts are always cold. You know, of course, that if you travel southward from where you live, you are going toward a warmer place. If you travel north, you are traveling toward a cooler place. You would expect, then, that wind blow-



Clouds in the sky keep some of the sun's heat away from the earth.

ing from the south would be warm and that wind blowing from the north would be cool. You can see that the direction of the wind will make a difference in the temperature of the air where you live.

Another thing that may change the temperature of the air is a change that takes place in the sky. Have you ever looked up into the sky on a hot summer day and said, "I wish it would get cloudy; then it would not be so warm"? When clouds come between the sun and the earth, they keep some of the heat away from the earth. Then the air is not so warm. In the summertime cloudy days are usually cooler than sunny days.

There are still other things that make the temperature of the air change. If you live near a large body of water, such as one of the Great Lakes or an ocean, the water may change the temperature of the air over the land. If the wind changes its direction so that the air blows from the water to the land, then the temperature on the land may drop.

You can see that there are many reasons why the temperature of the air is always changing. The temperature of a place depends upon where the place is, whether the sky is cloudy or sunny, and the direction of the wind. There is also the change of temperature that takes place between day and night. During the day the sun heats the side of the earth that is turned toward it. At night part of the earth's surface is turned away from the sun; so it gets no heat from the sun.

* * *

1. How is the air around the earth warmed?
2. When the sun shines, is the air over water warmer than the air over soil on the shore? Explain your answer.
3. Give as many reasons as you can to explain why the temperature of the air changes.

What makes the wind blow?

IN UNIT THREE you used a box, a candle, and some chimneys to make air move. The moving air in the box was really a wind. You will need to remember the things you learned in that experiment so that you can understand why winds blow.

To help you remember what you learned in Unit Three, do this experiment. Open a window at both top and bottom. Tie some strips of paper to a window stick. Hold the stick first at the top opening of the window and then at the bottom. In what direction does the air move? How do you know? Why did the paper blow out at the top opening?

Although air is not so heavy as water, air weighs more than you might think. If you could put on the scales a block of air three feet long, two feet wide, and two feet high, it would weigh about one pound. You know that there are miles of air above us. This great ocean of air that covers the earth is pressing down on the earth and on everything on the earth. A block of air one inch square and extending up as high as the air goes above the earth weighs almost fifteen pounds. This means that air is pressing down on the earth with a pressure almost equal to fifteen pounds on every square inch.

The higher up we go above the earth, the less air there will be to press down on us. So the higher we go into the air, the less the air-pressure will be. We live at the bottom of the ocean of air; so the air-pressure on us is greater than it would be if we were up in an airplane. The air-pressure is less on the top of a mountain than it is down in a valley. The higher the mountain is, the less the air-pressure will be at the mountain top.

Air presses in all directions. It acts in much the same way that water does. If you are swimming under water, there is water above you, below you, and on every side. It is pressing you from every side. You can feel it press. When you are on land, you are really walking around in an ocean of air. As you walk along, you push the air aside. It presses on you from every side. It presses upward, too, just as water does when you are swimming.

Here is an experiment that will help you to see that air presses upward. Fill a drinking glass entirely full of water. Then put a piece of cardboard over the top and press down on it. Hold the cardboard on the glass with one hand and carefully turn the glass upside down. Then take your hand away from the cardboard. What keeps the cardboard from falling? The air is pressing up on the cardboard and is holding it against the glass. The water is pushing down on the cardboard, but the air is pushing up on it with more force than the weight of the water.

Put a glass tube into a glass of water. Hold your finger over the end of the tube and lift the tube out of the water. Why does the water stay in the tube? Then remove your finger from the top of the tube and notice what happens. Why does the water run out?

When your finger closed the top of the tube, the air pressed up on the water and held it in the tube. But when your finger was taken away, the air pressed down as well as up on the water. The water then poured out of the tube.

From what you have learned in this unit and in the unit about heat, decide whether the following sentences say true things about air.

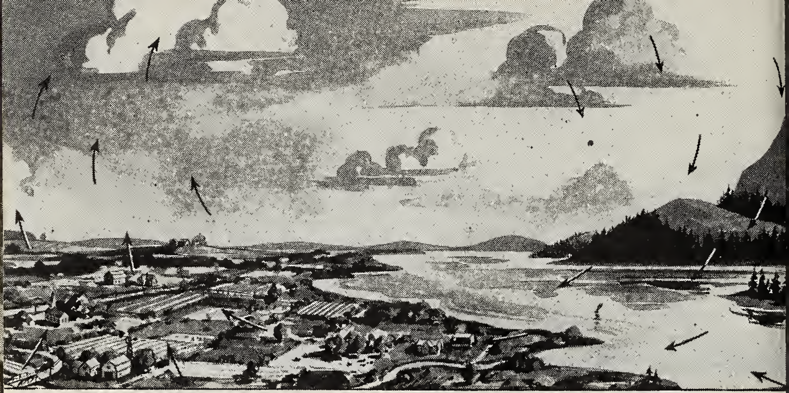
When air is heated, it expands and gets lighter.

Cold air weighs more than the same amount of warm air.

Cold air presses down harder than warm air because it weighs more.

If air is warm at one place and cold at another place, the cold air sinks and pushes up the warm air.

Now we shall see how these facts help us to understand why the wind blows. Let us imagine



The arrows in this picture show which way the air is moving. After you read pages 146 and 147, you will know why the air moves this way.

that we are standing high up on the side of a mountain. Below us is a great valley miles across and many miles long. In one part of this valley are meadows and fields. In another part are forests and a big lake. Suppose that we can see all of the valley. Let us also imagine that we can see all the air in the valley. It is early morning, and the air is cool and quiet, but it is soon going to move and make wind. We will watch to see what makes the wind blow.

The sun slowly comes up and shines on the valley. It shines on the rocks, soil, and grass in the meadows and fields, and makes them warm. The air next to the earth is warmed by the warm soil and rocks. In the shade of the forests the soil and the air are much cooler. The water in the lake is not warmed very much by the sun, either; so the air above the water is cooler than the air above the soil.

Soon the air over the fields and meadows gets very hot. As it is getting hotter, it is expanding and becoming much lighter. The cooler air over the lake pushes against the warm, light air in other parts of the valley. The cold air is settling down and pushing the warm air up. This starts the air moving. A wind has begun to blow.

The wind has started to blow because the air in some places in the valley is warmer and lighter in weight than the air in other places. If the air in different places is all about the same weight, then the air moves slowly, and we say that the wind blows gently. But if the air in some places is much heavier than the air in other places, the heavier air presses harder, and we say that there is a strong wind.

* * *

1. Which of these sentences are true statements of how the wind in your box experiment is like the wind out-of-doors?

a) They are both moving air.
b) They both move at the same speed.
c) They both move from a cold place to a warm place.
d) They are both moved by the same thing.

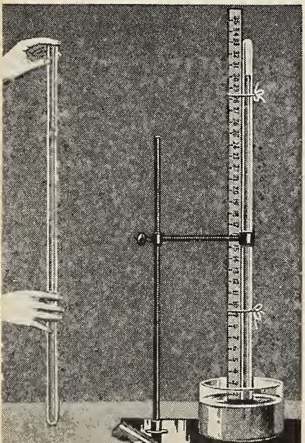
2. What makes the wind blow hard?

How do we measure air-pressure?

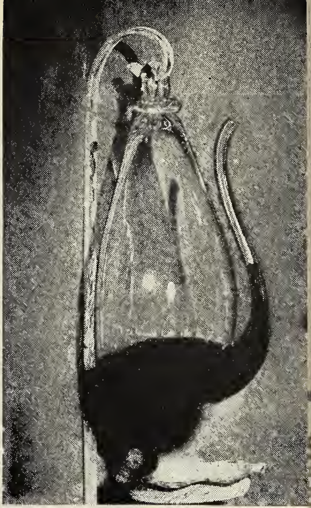
THE PRESSURE of the air around you is changing all the time. It may not be the same now as it was when you came to school this morning. It may change before you go home this afternoon. Before you come back tomorrow, it may change again.

Probably you are wondering how we know that the air-pressure is changing. You may say, "No one can see the air. How do you know that its pressure changes?" But scientists have learned how to measure the pressure of the air. The instrument they use to measure it is called a *barometer*. We use a thermometer to measure the temperature of the air. We use a barometer to measure the pressure of the air.

Perhaps you can find the necessary materials and make a barometer. If not, you can probably understand how the barometer works by looking at the picture below. To make a barometer, you will need the materials that are shown in the picture: some mercury, a glass tube about one yard long and closed at one end, a small dish, a yardstick, some string, and a ring stand.



Fill the glass tube with mercury. While you are filling it, hold the tube slanting so that the mercury will not strike the bottom of the tube too hard. When the tube has been filled, pour some mercury into the dish. Then put your finger over the open end of the tube and turn the tube upside down. Keep your finger on the end of the tube and put the end down into the dish of mercury.



Can you explain how this barometer works?

Hold the tube straight up, take your finger off the end, and watch the mercury. Tie the glass tube to the yardstick and fasten the yardstick to the ring stand. Now you have made a barometer.

Can you tell how this barometer measures the pressure of air? Try to answer the questions below, and then perhaps you can tell.

What happened to the mercury when you took your finger off the end of the tube?

Why did not all of the mercury run out of the tube?

Where does the air press against the mercury to hold it up?

If you watched the mercury when you took your finger off the end of the tube, you saw that at first the mercury began to run out. Then suddenly it stopped. The air pressing on the mercury in the dish was holding the mercury up in the tube.

If you look at the yardstick, you may see that the top of the mercury in the tube is about twenty-nine inches above the mercury in the dish. Do you see how this measures the pressure of the air? We say that the pressure of the air is equal to the weight of about twenty-nine inches of mercury. This means that the weight of the air pressing down on the mercury in the dish is holding up about twenty-nine inches of mercury in the tube.

Suppose the air presses down harder. Do you know what will happen to the mercury in the glass tube? This harder pressure on the mercury in the dish will push the mercury higher into the tube. Perhaps it will go up to thirty or thirty-one inches. If the air gets lighter, it will not press so hard on the mercury in the dish. Then more of the mercury will come down out of the glass tube into the dish. The mercury may drop to twenty-eight inches.

If you have a barometer in your school, keep a record of the changes in the height of the mercury for a week. Page 151 shows a record that some pupils once made. On what day of the week was the mercury highest? When was it lowest?

You have learned that the pressure of the air changes from day to day. Usually the air-pressure

	Monday April 2	Tuesday April 3	Wednesday April 4	Thursday April 5	Friday April 6
Barometer Reading at 9 o'clock	$29\frac{1}{2}$ inches	29 inches	$28\frac{3}{4}$ inches	29 inches	$29\frac{1}{4}$ inches

increases for several days, stays about the same for a short time, and then decreases for several days. Then it starts to increase again.

The reading of the barometer is very important to scientists who study the weather. When the air-pressure is so great that it forces the mercury high up in the tube, we say the air-pressure is *high*. When the air-pressure is rising, we usually have fair weather. When the mercury is low in the barometer tube, we say that the air-pressure is *low*. Low air-pressure usually brings stormy weather. You know, too, that if the air-pressure is less in one place than in another, a wind will blow. It blows from the place of high pressure to the place of low pressure.

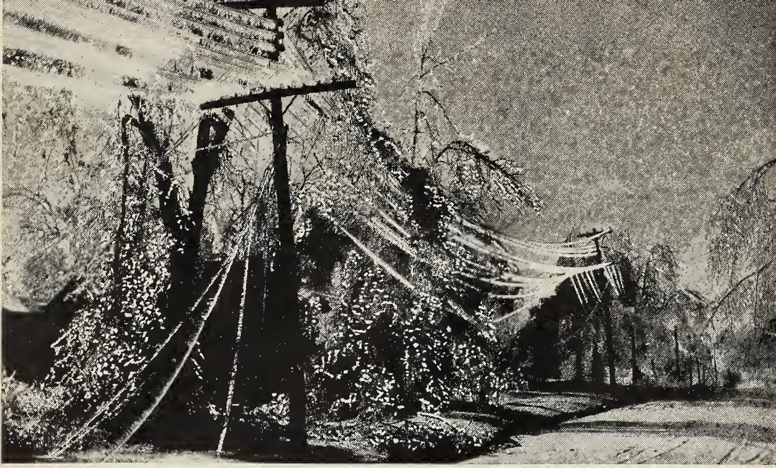
* * *

What would happen to the mercury in a barometer if:

a) You made the air-pressure around it greater?

b) You took all the air away from around the dish of mercury?

c) The air-pressure changed every hour?



This is what happens when water comes out of the air in very cold weather. It has frozen on trees and telephone wires. The ice is so heavy that it has broken down the trees and the wires.

What makes it rain and snow?

YOU HAVE found out many important things to help you understand why the weather changes. You have learned that air has weight and presses down on the surface of the earth. You know that this pressure can be measured with a barometer. And you know that if the air-pressure is higher in one place than in another, a wind will blow. You know that winds bring changes in temperature.

There are more things to learn about weather. Rain, snow, fog, sleet, and hail are just as much a part of weather as wind and temperature. Probably you have often said, "It looks like rain," or

"I think it is going to rain." Why did it look like rain? Why did you think it was going to rain?

You know that sometimes the sky is clear, without a cloud in sight. In a few hours great clouds may appear, and soon the air is full of rain-drops or snowflakes. The rainy or snowy weather may be followed by a day of fair weather; then there may be a thick fog. Rain, snow, sleet, and hail are all made by water coming out of the air. What makes water come out of the air in these ways?

You should be able to tell why the water comes out of the air. Turn to pages 126 and 128. Read them carefully. Then answer these questions:

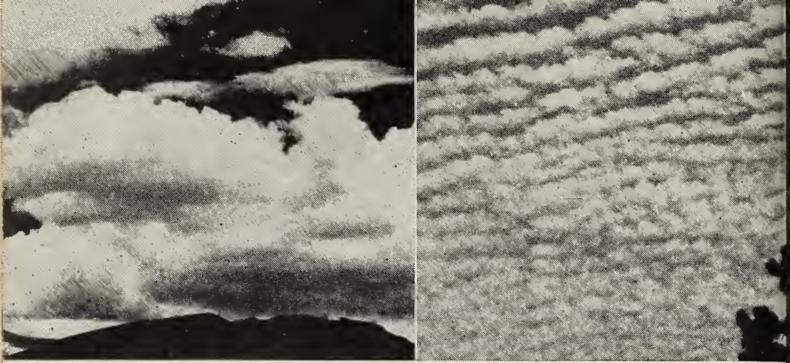
What does "evaporate" mean?

What does "condense" mean?

Which evaporates more rapidly—cold water or warm water?

Do you know which can hold more water, warm air or cold air? This experiment will help you find out. Fill a tin cup or can with cracked ice. Let it stand for awhile. What appears on the outside of the cup? Where did the water come from?

This is what happened in the experiment. When you first put the ice in the cup, the cup was warm. The air around the cup was warm, too. Then the ice made the cup cold, and the cold cup cooled the air that touched it. You know that there is always some water vapor in the air. When the air around

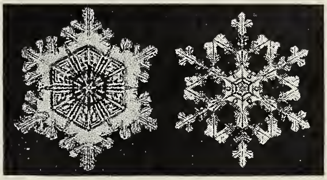


Big white fleecy clouds like the one at left usually mean that rain is coming. The clouds at the right make what is often called a mackerel sky because the clouds look like the wavy colored streaks on a mackerel.

the cup became cool, it could not hold the water vapor that was in it. So the vapor condensed into the liquid water on the cup.

Now let us see why it rains. Wherever there is a pond, a lake, a river, or an ocean, water is always changing to water vapor and passing into the air. Water from wet soil also passes into the air. The warmer the water, the faster it evaporates. And the warmer the air, the more water vapor it can hold. What do you suppose happens when air is cooled? Cold air cannot hold so much water vapor as warm air. When air that contains much water vapor is cooled, some of the water vapor condenses and comes out of the air.

When you see a cloud in the sky, you see a great mass of condensed water vapor. When you boil water in a tea-kettle, you are making a real cloud. The white cloud near the end of the spout is made of tiny drops of water. The steam condensed when the cooler air of the room struck it. Clouds in the sky are made of very, very tiny droplets of water floating in the air. If the air in the clouds gets colder, more water vapor will condense. The tiny droplets join together to make larger drops. Finally they cannot stay up in the air, and they begin to tumble down to the earth. Then we have rain!



These are snowflakes as they look through a microscope.

Sometimes the air has only a very little water vapor in it. If this air is cooled to a temperature below freezing, the water vapor will condense to a solid. Then we have snow. The vapor condenses so quickly that it forms fairy-like snowflakes. You can find many beautiful patterns in the snowflakes. They always have six sides or six points, but there are never two flakes exactly alike. The next time it snows, let some of the flakes fall on your coat-sleeve and examine them with a magnifying-glass.

Sometimes, as the drops of rain fall from the cloud, they pass through air where the temperature is below freezing. Then we have *hail* or *sleet.*

Have you seen drops of dew on the grass? The hailstones in the picture at the right are much larger than a hen's egg!

On a summer morning you go out into the yard and find that the grass is wet with *dew*. In the fall, when the weather is colder, the grass and the roofs may be covered with white *frost*. Where do you think the dew and the frost come from? People used to think that they came from the ground. But dew and frost come from the air. Let us see how they are made.

Suppose that it is a warm clear summer day. After the sun goes down, the soil, the buildings, and the plants become cool. The air that touches these cool things also becomes cool. Then this cool air cannot hold the water vapor it took up during the day. So the water vapor condenses into dew on the plants, the soil, and the housetops.

But in the fall the temperature during the night may fall to below freezing, and the water vapor may change to a solid just as it does when snow is made. Then we would have frost.

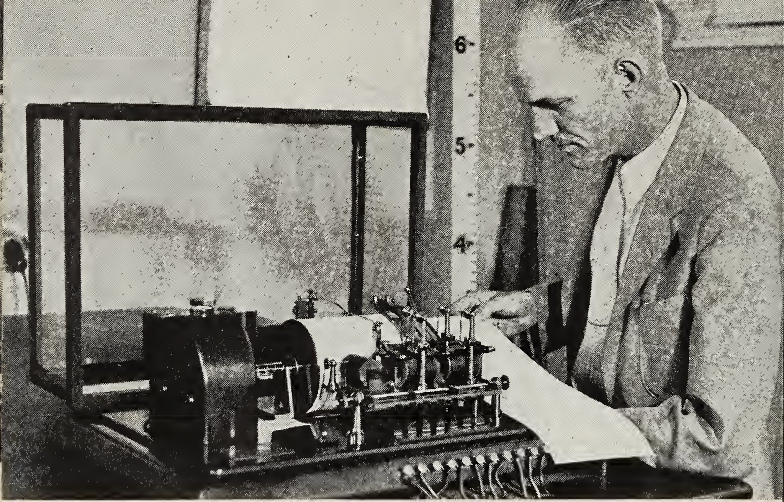
Have you ever seen a fog? If you have, you have really seen a cloud close to the earth. Fog is just a big cloud close to the earth. Sometimes a fog is so dense that you can see only a short distance in front of you. You know that a cloud is condensed water vapor, and that is what a fog is.

* * *

1. Why do iron pipes that carry cold water often have drops of water on them in summer?
2. How would our weather be different if water could not evaporate?
3. In what ways is warm air different from cold air?
4. What is dew? What is frost?
5. Just how would you use a tea-kettle of boiling water to explain to someone how rain is made?
6. Do you believe what these sentences say? Why?

a) We could not have rainy weather without the help of gravity.

b) Water that is now in a mud puddle may sometime fall from the sky.



Machines such as this help the scientists at the weather bureau to be more certain that their weather forecast is correct.

How does the "weather man" find out what the weather will be?

WHEN you want to know about tomorrow's weather, you look in your newspaper or listen to the weather report on the radio. This weather report is made by the weather bureau. We say that its work is to *forecast* the weather. "Forecast" means tell what is coming.

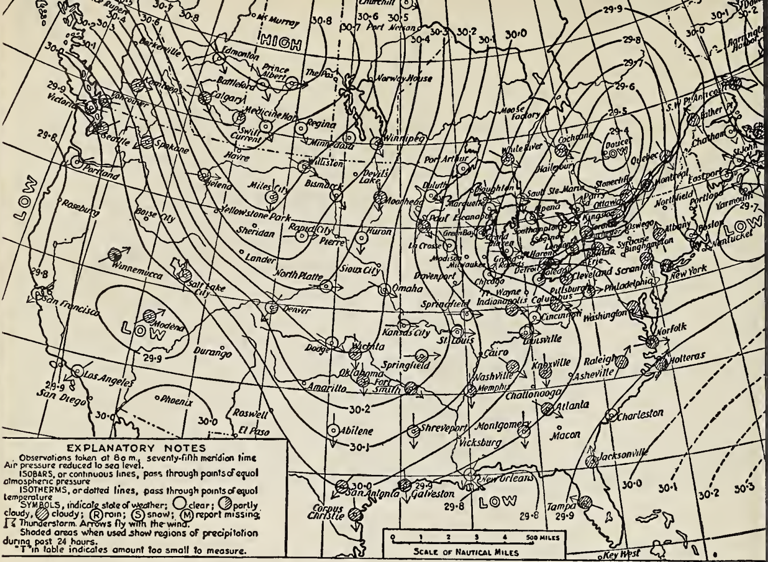
The work of forecasting the weather is done by scientists who have studied weather very carefully and have watched its changes for many years. They have kept records of the air-pressure and the temperature. They have studied the clouds and have found out what kinds of weather the different kinds of clouds are likely to bring.

The scientists at the weather bureau also keep records to show how the weather has changed from month to month for many years. They can tell you the hottest day and the coldest day in every year for years gone by. They can tell you about how much rain or snow usually falls during any month in the year and about how much sunshine there usually is in every part of our country.

Many people all over the Dominion of Canada want to know the weather forecast for the place where they live. So the scientists of the weather bureau have found a way to tell them. The scientists make a *weather map* of North America. This map is really a newspaper that tells the news of the weather. It tells what the temperature is in different places. It shows wind direction, speed of the wind, amount of rain or snow, and air-pressure for places all over North America.

A new weather map is made for every day. When the map for the day has been made, the weather forecaster studies this newspaper of the weather; then he forecasts what the weather will probably be on the next day.

On page 160 is a copy of a weather map which was made from reports sent in by weather stations in different parts of Canada and the United States.



Courtesy Meteorological Service of Canada.

At first this map may seem to be just a jumble of lines to you. But look at it closely. Do you see that it is a map of part of North America? Can you find a town near you? Many of the towns shown have weather stations. By sending in weather reports these weather stations help the weather bureau in Toronto, Winnipeg, and Victoria where weather maps are made. There are hundreds of these weather stations in towns scattered all over the country.

These weather stations send reports twice a day. They make the following records for the places where they are: the air-pressure (reading of the barometer), the direction and speed of the wind, the amount of rain or snow, and the highest and lowest temperatures of the day before. Then they send the records by telegraph to the cities where the maps are made.

As soon as the scientists at the weather bureau receive all this information, they begin to make the weather map. All of the records are placed on the map; then the weather scientist studies the news of the weather. He decides what the weather forecast should be for different parts of the country. Then he telegraphs the forecasts to many places in North America. They are printed in newspapers and broadcast from almost every radio station.

A weather map is difficult to understand. You need to know much more about weather than you have learned in this unit before you can understand the map. But when the forecaster reads this weather map, he finds many important things to help him tell how the weather is likely to change. On the map you will find places marked "high" and "low." "High" means a place where the air-pressure is high. "Low" means a place where the air-pressure is low. These places of high pressure and of low pressure change from time to time. They move across the country. The weather forecaster has studied this movement of "highs" and "lows" for many years, and he can tell which direction they will probably move and how fast they will move. The forecaster has found that the weather will probably be clear and cooler when the air-pressure is increasing. He has also found that the weather will probably be stormy and warmer when the air-pressure is decreasing. This helps him tell when it will be clear weather and when it will be stormy weather.

Of course, the forecaster is not always correct in his forecasts. Sometimes the air does not move just as he thinks it will. Then his forecast may not be accurate.

You may wish to keep a record of the reports to see how nearly they are correct for the place where you live. You must remember that the report is usually made for a large part of the province. If the forecast is "showers," you must remember that it may be raining two miles away, but there may not be even a sprinkle on your house. Then you must not say that the forecast is wrong. Whenever you try to prove that anything is right or wrong, you must do it carefully as a scientist would do it.

* * *

1. What things do scientists need to watch so that they can forecast the weather?

2. What are some of the things that a scientist can find out by looking at a weather map?

3. Why is the weather forecast not always correct for the place where you live?

How are the weather forecasts used?

MANY people change their plans when they hear the reports of the weather bureau. Here is a list of things that happened because the weather report said, "Much colder with strong north wind. Probably heavy snow within 24 hours."

Snow was forecast; so this snow-plow was ready to go to work.

Hundreds of people put on heavier coats and sweaters when they left home to go to school and to work.

Steamship companies warned all their boats to get ready for a storm or to hurry to a harbor.

The air-lines sent radio messages to their planes. Many planes were not allowed to start on long trips.

People fixed their storm-windows and doors. Many of them telephoned for more coal to be brought to their houses.

Railroad men and fruit-growers packed fruit and vegetables more carefully so that the food would reach the customers without being frozen on the way.

The Highway Departments made their snow-plows ready so that they could begin to plow the snow out of the roads as soon as it fell.

Millions of dollars and hundreds of lives are saved every year because of the work of the weather bureau. Airplane pilots make much use of the reports of the weather bureau. The airports also have scientists who study the weather. They watch barometers and thermometers to tell how the air is changing. They watch to see how the direction of the wind is changing, too. They need to know about temperatures in the air high above the earth, and they need to know when to expect fogs and storms.

Shippers need the reports of the weather bureau so that their boats can make safe journeys. In winter the weather reports help them to decide just how they must pack fruits and vegetables so that they will not freeze. In summer shippers use the weather reports to help them decide how cool such food must be kept so that it will not spoil.

Fruit-growers watch the weather reports carefully at certain times of the year. If a heavy frost comes when the fruit trees are in blossom the blossoms may be frozen; then there will be no fruit. Sometimes fruit-growers build fires in their orchards to warm the air and help keep the blossoms from freezing. See the picture on page 165.

Farmers watch the weather bureau reports for warnings of approaching storms. At harvest time if the report forecasts rain, the harvesters hurry to get grain or hay into their barns or to put it into

stacks so that the rain will not spoil it. Of course, sometimes showers come without warning. Changes in the air may happen so quickly that the weather bureau cannot forecast them.

Can you remember some of the times when you have needed to change your plans because of changes in the weather like these:

Rain spoiled your plans for a picnic.

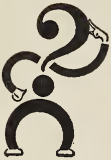
Sudden warm weather melted the ice in a pond, and you could not skate.

The weather became suddenly colder, and you could not go swimming.

A shower came up when you were away from home, and your clothes were soaked.

Now that you know about the work of the weather bureau, its reports may be of greater help to you in planning your work and play.

Questions to Answer



1. Why can you see your breath only on a cold day?

2. On a hot summer day which will get hotter—the black top of an automobile or the glass in the windows?

3. The winds blow from the Pacific Ocean across British Columbia and across Washington, Oregon, and California. When they strike the Rocky Mountains, they are pushed high up where it is colder. Where do you think the most rain falls—in British Columbia and Washington, California, and Oregon or in the region on the eastern side of the mountains?

4. Where does dew go when it disappears?

5. Why do fogs more often come at night than in the day? What makes the fog disappear?

Things to Find Out

1. Keep a record of the weather reports for two weeks and see how many times the report is wrong. Give the "weather man" a grade for each day.

2. Clip the weather forecast from your newspaper and bring it to school. Make a list of the things you have learned in the study of this unit that help you understand the report.

3. Write a paragraph that tells why you think that the weather bureau reports are very important.

4. Make a wind vane and place it where you can easily see it. From what direction does the wind blow most of the time?

5. Find out how much rain falls in one week where you live. You can make a rain gauge by placing an open can on a post in a spot that is not sheltered by trees or buildings. Each time it rains, measure the rainfall with a ruler.

UNIT FIVE

HOW DOES THE SURFACE OF THE EARTH CHANGE?

Before you begin to study this unit, suppose you do a little thinking about the land near where you live. Is it level or hilly? Are there any mountains? Are there rivers or lakes near by? What kinds of rocks can you find?

Can you think of some ways in which you have seen the land change? Perhaps you think you have never seen changes in the land. But you probably have seen them. Have you seen the banks of the rivers and creeks cave in or wash away? Does the rain ever wash big holes in dirt roads? Does the wind ever pile the soil up into big heaps? These are some of the changes that you can see in the surface, or the outside part, of the earth.

The surface of the earth is changing every day. It has changed since yesterday, and tomorrow it will be different from the way it is today. Do you know that the highest mountains in our country were once under water? Some great forces pushed them up out of the water. And now these mountains are getting lower every year.

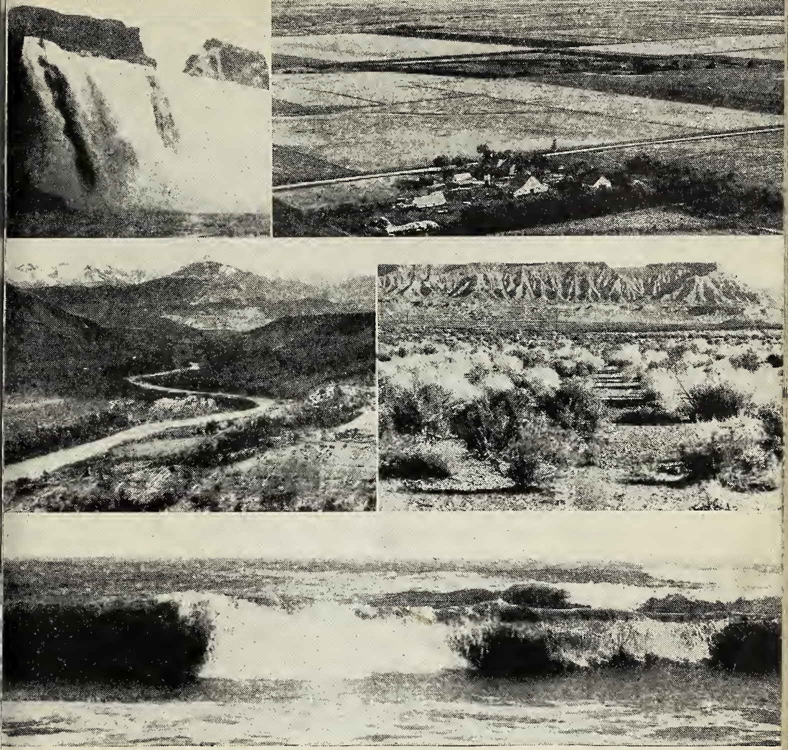
Today men in our country are worried because millions of acres of farm land are being ruined. Tons and tons of good soil are being carried away from the land. The food plants that we need cannot grow where the good, rich soil has been carried away. Do you know what it is that carries the rich soil away?

In this unit you are going to learn the answers to these questions. You will find out about some great forces that are changing the surface of the earth every day by moving parts of it from one place to another. When you have finished the unit, you will know why the surface of the earth looks the way it does, and you will know how it is changing.

What does the earth's surface look like?

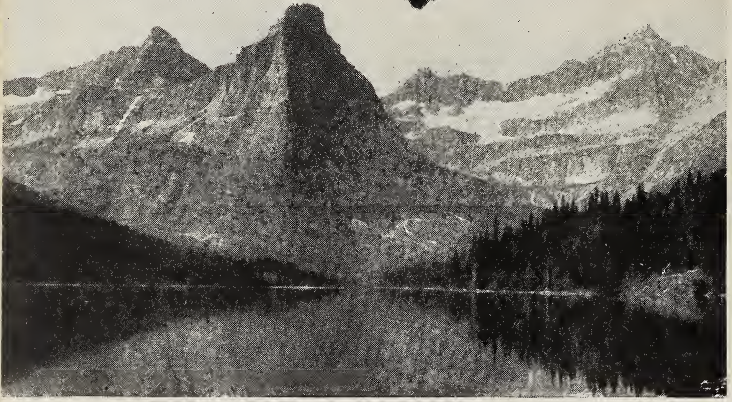
WHAT do you think a bird's-eye view of the earth would look like? Perhaps you have been up in an airplane and have looked down on miles and miles of the earth's surface. Pretend that you are looking at the earth from a very high place. Imagine that you can see from one side of our country to the other.

Those great bodies of water that you see along the sides of our country are the oceans. More than three-fourths of the surface of the earth is covered by water. Besides the great oceans, there are many smaller bodies of water. Some of these are



These pictures show different parts of the earth's surface.

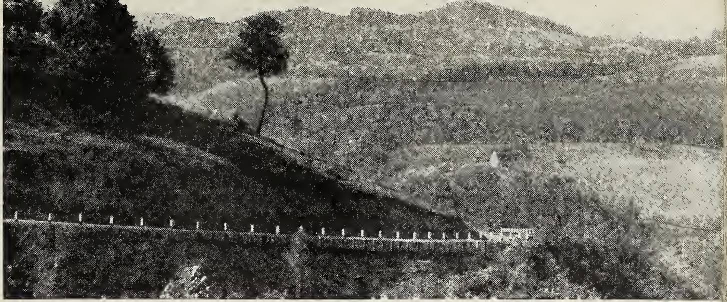
seas; some are large lakes. Look more closely, and you will see hundreds of smaller lakes. You will also see long ribbons of water flowing across the land. These are rivers, and some of them are hundreds of miles long. If you were closer to the earth, you would see still smaller streams creeping across fields or rushing down mountainsides.



Probably the mountains in the picture on the next page once had sharp peaks like those in the picture above. These sharp peaks will some day be worn down into mountain tops with gently sloping sides.

These great rivers and the small creeks and brooks are alike in one way. They are all traveling downhill. Some hurry along at a great speed. Others flow slowly. But they are all running downhill and pouring their waters into low places on the earth's surface.

Now look more closely at the land. Here and there are great level stretches. Some of these are covered with forests. Some of them are grass-covered prairies. Others are deserts with almost nothing growing on them. In other places the land is hilly. You see miles of hills and valleys. What are those places that look so rough and jagged? They are mountains. Some of the mountain peaks are more than three miles high! Study the pictures



on page 171 to see how different the earth's surface looks in different places.

If we could see the surface of the earth the way it looked several hundred years ago, it would not look the same as it does today. And it will not be the same at the end of the next several hundred years. It is changing, changing, changing!

Let us imagine that we can speed up all the changes that are taking place in the earth's surface. We know that these changes really take place very slowly. But in our imagination we are speeding them up to thousands of times their real speed. In this way we make the changes take place so fast that we can easily see what is happening. We are amazed at what we see. The high mountains are getting lower and lower. Some valleys are getting deeper and deeper. Other valleys are getting wider and wider. There is a lake that seems to be filling up with soil, and the water is spilling out into rivers. Soon there is no lake left.

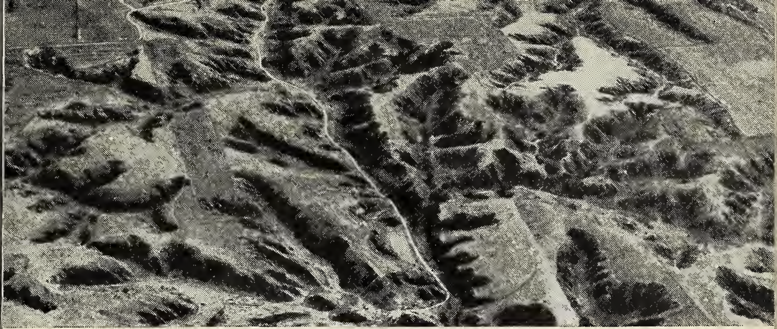
At the mouth of a big river that flows into the ocean, land begins to rise out of the water. More and more land appears, and the river breaks up into many channels running through this new land. Instead of just one mouth, the river soon has many mouths.

All these changes really do happen, but they go on very, very slowly. You can see some of the little changes that are happening if you watch what is going on around you. Let us learn how these changes take place.

How does water change the surface of the earth?

WATER is one of the most important of the giant movers that change the land. Every day is a moving day for water. It is at work night and day. The water in the rivers and streams all over the surface of our country is traveling downhill to the low places. You remember that moving water has force and that it can make things move along with it. If you throw a stick into a river, the moving water carries the stick along. As the water in rivers flows on its way, it carries part of the earth along with it.

You will want to take a trip out-of-doors to see how this moving takes place. Go out some day after there has been a heavy rain, or the snow has begun to melt. Notice that some of this water soaks into the ground, but much of it begins to



Do you see how heavy rains have washed gullies all through this land? They have washed away much of the good soil from the fields. Now these farms cannot raise the crops that they once raised.

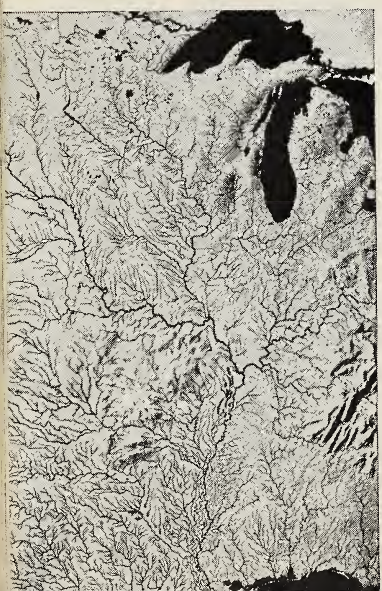
gather in streams. At first the streams are small, but they flow into each other until they make a larger stream.

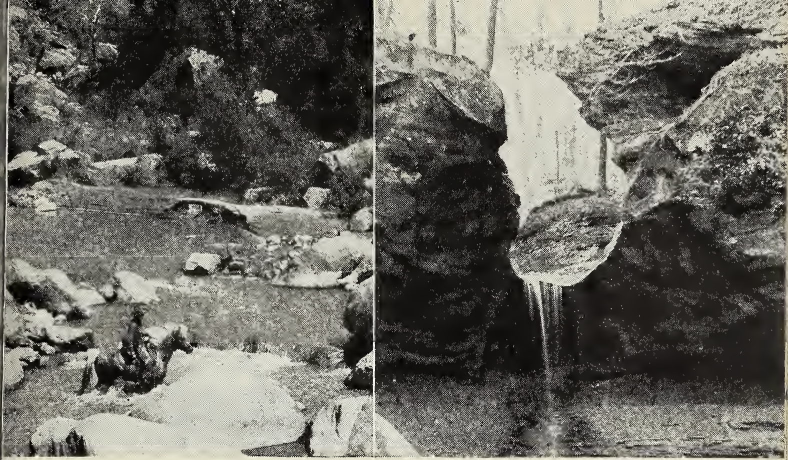
Follow the stream as it goes downhill. Soon it is joined by other streams, and now it has become a good-sized creek that flows down a little valley. But the water is no longer clear as it was when it fell from the sky or melted from snow. It is a muddy color.

Dip a drinking glass into this stream and fill it with water. Then hold the glass up in the sunlight and look through it. You can see what makes the dirty brown color. Thousands of tiny specks are everywhere in the water. Do you know what they are? They are grains of soil that have been washed away from the land by the stream. If you pour the glass of water back into the stream, these grains of soil again will start their journey downhill with the water. Some of them will settle to the bottom of the stream. Some of them may be carried all the way to the ocean and become part of the ocean bottom.

The next time it rains, see if you can find a place where the water has moved some soil. Perhaps you can find soil washed on to the sidewalk or street pavement.

One of the greatest movers of soil in North America is the Mississippi River, which is shown below. Do you see how the small streams flow together to make larger ones, and how many of these larger ones keep adding themselves together to make the Mississippi? The water in all of these streams is moving soil downhill to the sea. How much soil do you suppose this great river carries to the sea every day? In one day it moves more than a million tons of soil into the Gulf of Mexico. If men had to move all this soil in one day, they would need 7500 trucks. Each truck would have to dump a load of



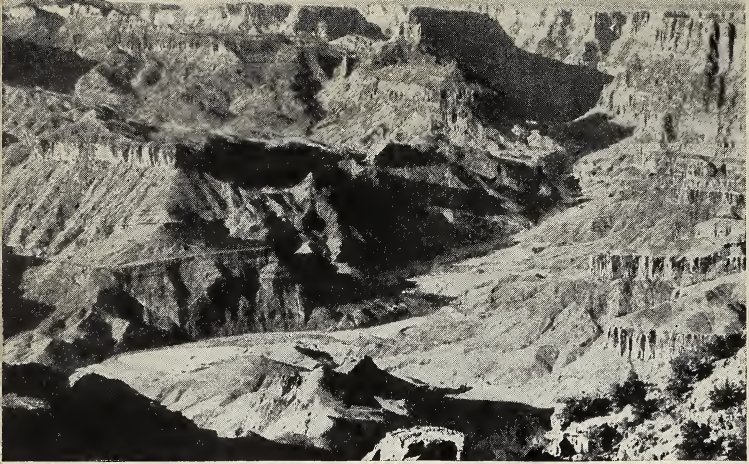


Notice how the water in the creek has smoothed the rocks. In the second picture water is cutting through solid rock!

soil into the Gulf of Mexico every hour of the day to get the work done!

The force of the water can move things that are larger than grains of soil, too. Have you ever watched a mountain stream? If you look into the bottom of such a stream, you will find that it is covered with stones. Many of these stones came from far up the stream. They were rolled along by the fast-moving water as it rushed down the mountainside.

The moving water wears these stones away, too. As the stones churn around in the water and are rubbed against each other, tiny parts of them are worn off, and the water carries these parts away. In this way a piece of rock from far up on a mountain

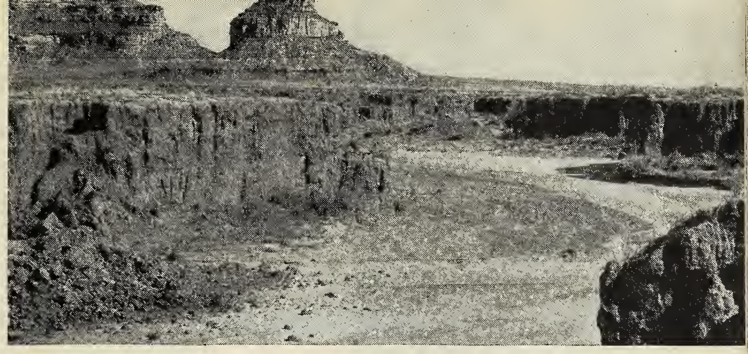


The Grand Canyon of the Colorado River is over a mile deep and more than two hundred miles long.

may some day be ground into soil and carried down into a valley.

The running water sometimes uses the stones as tools, too. As the force of the water rolls these stones along, they dig out the soil at the bottom, or *bed*, of the stream. A swiftly flowing river keeps wearing away its bed. It makes the bed deeper and deeper as the years go by.

Look at the picture of the deep bed of the Colorado River. Such a deep place as this is called a *canyon*. Thousands and thousands of years have passed since the Colorado River began to make its bed. In one year the river does not make enough change for you to notice. But after thousands of years, the river has cut a deep path into the earth. The



In the two pictures on this page notice the piles of earth and rock that have caved in along the river banks. Soon they will be carried away by water. The stream-bed above is dry now, but it will be filled with rushing water after hard rains.

wearing away of a river bed is very slow, but it is very sure.

The force of water helps to change the earth in still another way. If it is freezing weather, you can try an experiment to find what this other way is. Fill a bottle with water and set it outdoors on a night when the temperature is below freezing. Put a cork in the bottle and wire the cork on.

When you look at the bottle next morning, what do you find has happened to it? Did the water expand as it froze? As it expanded, it pushed against the sides of the bottle until finally the glass cracked. When water freezes, it has enough force to break iron

How do you think the cracks were made in this big rock?

pipes. You may have heard of water pipes bursting in houses because the water in the pipes froze solid.

Perhaps you see now how freezing water can change the earth. When rain falls on rocks or snow melts on them, the water trickles down into tiny cracks in the rocks. When cold weather comes, this water freezes, expands, and cracks the rocks. This force of freezing water keeps breaking the rocks into smaller pieces. Great mountains of rock are slowly being broken down in this way.

Changes in temperature cause the breaking of rocks in another way. Bare rocks get very hot when the sun shines on them. Perhaps you have sat on one that was too hot for your comfort. When rocks are heated like this, they expand. Rocks also get very cold at times. Then they contract. Some parts of the rocks expand and contract more than other parts. This causes cracks in the rocks.

You can understand how changes in temperature make rocks crack if you remember what happens when you pour hot water on cold drinking glasses. The glasses will often crack. Rocks act the same way. The inside of the rock may be cold. The outside gets hot and expands. As it gets bigger, it breaks away from the rest of the rock that is not expanding.

You will find it interesting to hunt for cracks in rocks and in concrete or stone sidewalks. What do you think made these cracks?

1. Why are rivers and streams usually muddy after a heavy rain and in the spring when the snows are melting?

2. Break a rock by using a chisel and a hammer. Notice how sharp the edges are. Why are many of the stones you find along rivers so smooth and round?

3. Some boys once found what they thought was a round, smooth red stone in a mountain stream. A scientist told them it was a piece of brick. How did it get so round and smooth?

4. Explain how pieces of a big rock that is now on the top of a mountain may some day be on the bottom of an ocean or a lake far away.

5. Why are the beds of mountain streams usually covered with big stones or gravel instead of mud?

6. In what two ways does the force of moving water change the earth's surface?

7. How does freezing water crack rocks?

Do you know how wind made these hills of sand?

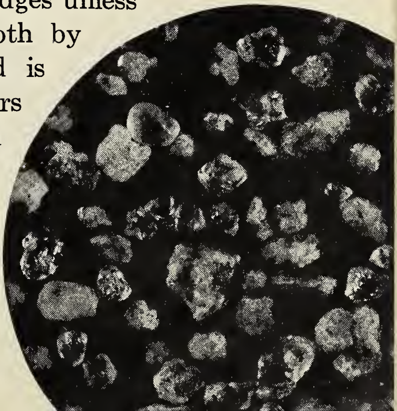
How does air change the surface of the earth?

BESIDES the water on the earth there is another great mover that is changing things. You have never seen it. But you have felt it, and you have seen work that it has done. This mover is moving air. We call it wind. When wind blows across dry land, it picks up sand or grains of soil and blows it along.

Many times you have seen great clouds of dust blown along by the wind. Perhaps you live in the part of our country where the terrible dust-storms have taken place. In these storms thousands of tons of soil have been moved from one place to another. Sometimes the soil has covered up houses and barns. Great quantities of soil have been carried for hundreds of miles and dropped in other parts of our country.

In some places the wind piles up sand to make high hills. The wind carrying the sand comes to a little hill or some bushes or trees. These stop the sand, and it falls to the ground. More sand is carried to the little hill, and it becomes bigger and bigger. We call such hills sand *dunes*. If you would like to make some small sand dunes, stick a small board and some twigs down in the sand near one end of a sand-table. Then stand at the other end of the table and fan close to the sand. Does the wind from the fan blow the sand along the table? Does the sand finally cover the board and the twigs?

Wind changes the earth's surface in another way. Wind and the sand that it carries can cut rocks into pieces. If you look at sand under a microscope, you will see something like the picture on this page. Grains of sand have sharp edges unless they have been worn smooth by moving water. When sand is blown against stone, it wears the stone away. The wind uses the grains of sand as tools to grind away rocks. The wind and the sand take a long, long time to

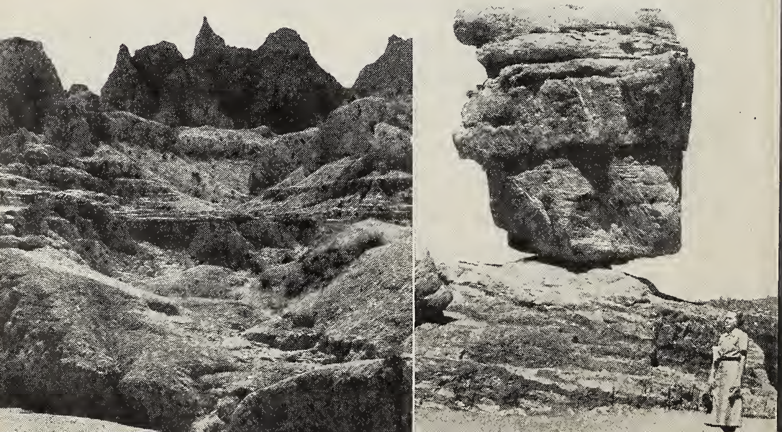


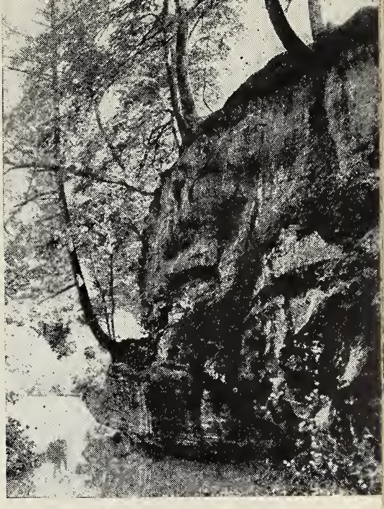
cut deeply into a rock, but after many years the rock will become smaller.

The pictures below show rocks that have been worn away by wind and sand. For hundreds of years the wind has blown against these rocks. The softer parts of the rocks have been worn away, and the harder parts have been left. Do you see why these rocks are in such strange shapes?

* * *

1. In what two ways does moving air change the surface of the earth?
2. How are sand dunes made?
3. Tell a number of ways in which rocks are broken up and ground to pieces.
4. Turn to page 170, read the first paragraph, and describe two ways in which good farm soil may be carried away.





See how the trees are growing out of this rock. What do you think their roots are doing to the rock?

How do plants change the earth's surface?

WOULD you believe that plants can break rocks? Can you think how this is possible? Seeds of trees and other plants are blown about by the wind. Some of them fall on rocky places on the mountains or on large stones in the fields and valleys. Perhaps there is a bit of soil on the rocky place. The seeds may fall on this soil. The rain wets the soil, the seeds begin to sprout, and the tiny plants send out rootlets into the rock.

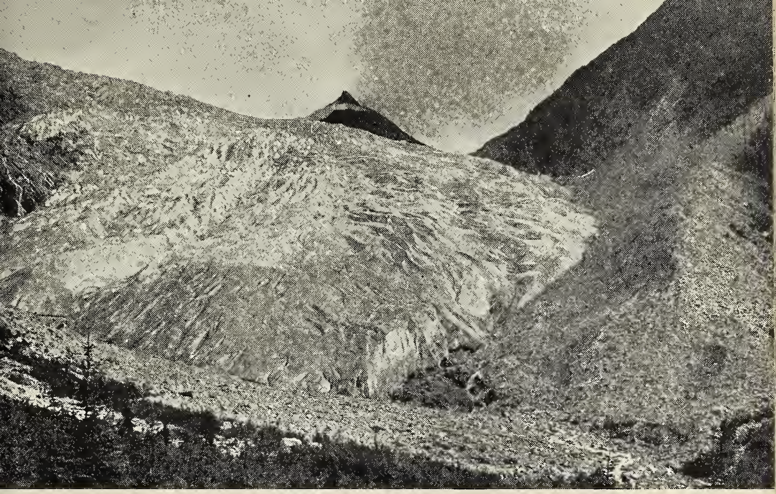
These rootlets can squeeze into the smallest crack or hole. Hundreds of them begin to force their way into the rock. They grow bigger and bigger. The growing roots split the rock. They keep splitting the rock until it breaks into pieces. Have you ever seen sidewalks broken by tree roots? Sometimes a water pipe under the ground is broken open by tree roots. Some rootlets find their way into a little crack in the pipe. When they grow larger, they break the pipe.

How have glaciers changed the surface of the earth?

When Admiral Byrd and his explorers were at the South Pole, they decided to find out how thick the ice was that covered the land. They had scientific instruments to help them. What do you suppose they learned? At the place where they were, the ice was two miles thick! That seems almost impossible, doesn't it? But it is true. Do you know where Greenland is—out in the North Atlantic Ocean? Greenland is almost entirely covered with a great sheet of ice. In some places this ice is many hundreds of feet thick.

Now the next statement may surprise you, too. Thousands and thousands of years ago, a large part of North America was covered with a great ice-sheet just as Greenland is now. And what is even stranger, this great ice-sheet, or *glacier*, was moving. It moved very, very slowly—only a few feet each year. It moved down from the north like a great river of ice.

As the glacier moved along, it changed everything that it touched. When it came to a hill, it pushed off the top of the hill and then crept on its way, carrying its load of dirt from the hill. When it came to large rocks, it picked the rocks up, too. Slowly the glacier pushed the rocks along, scraping and scooping out great holes in the earth.

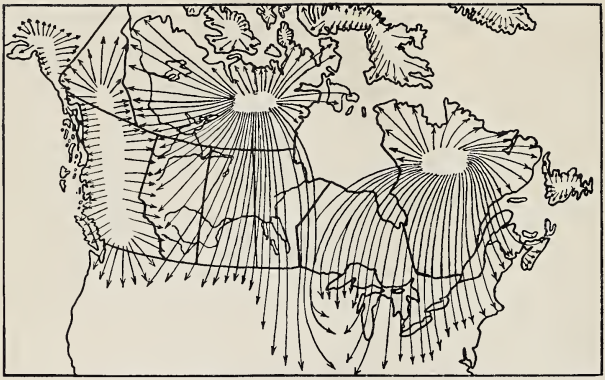


Here is the end of a glacier near Glacier, British Columbia. You can see the rocks and soil that were dropped when the edges of the ice melted.

On and on it pushed. Finally it got down as far south in the United States as the state of Ohio.

Then the climate became warmer, and the glacier began to melt. The soil that had been carried along was dropped. In some places it made high hills. Rocks that had been picked up in Canada were dropped as far south as Ohio. When the ice melted, there was a great amount of water. The water ran into the low places that the glacier had dug out. This made lakes. Lake Superior and the other Great Lakes were made in this way.

Several times there have been thick sheets of ice that moved downward from the poles of the



earth. We do not know much about any of these great ice-sheets except the last one. The map on this page shows the parts of Canada and the United States that were covered by the last glacier.

When you drive through the country, you will see hundreds of hills and valleys that were made by the great sheet of ice. You will also see many lakes that were made when the glacier dug out big holes in the earth.

* * *

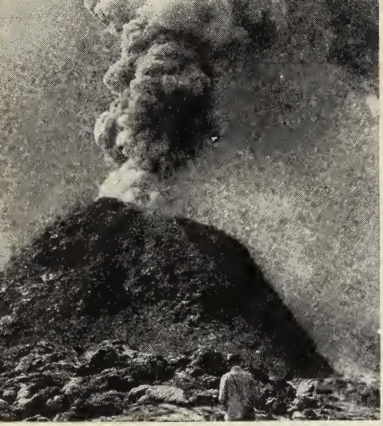
1. What is a glacier?
2. Tell how glaciers made lakes.
3. Tell how glaciers made hills.
4. Why do scientists believe that a large part of North America was once covered by glaciers?
5. Where could you find glaciers today?

How do volcanoes build up the earth's surface?

FOR MILLIONS of years the forces of moving air and water have been tearing down the hills and the mountains. Perhaps you are wondering why the earth is not all level. There are other forces that are pushing parts of the earth up and pouring material from the inside of the earth out upon the surface. Let us see how one of these forces builds up some of the low places.

If you live on the west coast, part of the soil of your province was once inside the earth. Volcanoes blew it out of the earth and spread it over the land. There is a place nine hundred miles long and one hundred miles wide where the soil was made from rocks that came from volcanoes. In one place in the United States a river has cut a deep canyon. In the walls of the canyon, scientists have counted thirty layers of rocky material. The rocks were blown out of volcanoes at different times and fell back to earth there.

There are many things that scientists do not know about volcanoes. But this is what they think makes volcanoes. The inside of the earth, they believe, is made of mixtures of different kinds of rock. The inside of the earth is also very, very hot. It is so hot that in some places the solid rock has become a liquid. This hot material contains steam and other gases.



Notice the shape of this volcano, and the lava at its base.

The liquid rock containing gases is lighter than the rock around it. This liquid rock is pushed upward and flows out through a weak spot or a crack in the earth's surface. When this happens, a volcano is formed. When the liquid rock comes out of the volcano, it cools and hardens again into solid rock. This rock is called *lava*. Sometimes the lava flows out quietly. Millions and millions of tons of lava have been poured out on to the land in many parts of the world. The wind and rain and sun and plants slowly crumble this lava and change it into a part of the soil.

Sometimes the weak spot in the earth, or the crack, is so small that the lava cannot flow out fast enough. Then the volcano explodes. We say that it *erupts*. Steam pours out, and tiny bits of hot rock fly up into the air. Some of the rock falls back to the earth on, or near, the volcano. Some of it may be carried by the wind to places far away. When it lands on the ground, it looks like ashes. But it is really rock that has been blown to bits by the force of the explosion.

This rock was very hot liquid when it came from inside the earth.

Sometimes the steam condenses into water and makes mud of the powdered rock. Then it may really "rain mud."

When a volcano erupts many, many times, it slowly builds up a mountain. The lava and the lava dust keep building up around the opening. Finally there is a mountain, thousands of feet high, with a great hole in the top of it. This hole is called the *crater* of the volcano.

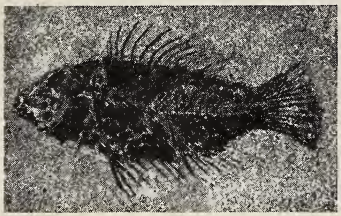
Mt. Shasta and Lassen Peak in California and Mt. Rainier in Washington are old volcano mountains. They do not erupt any more, although Lassen Peak did send up hot steam and mud about twenty-five years ago.

* * *

1. What is lava?
2. What is a crater?
3. What happens to lava after it leaves the crater of a volcano?
4. Why does it sometimes "rain mud"?
5. How do scientists believe volcanoes are formed?

How are mountain-ranges made?

Look at the picture on this page. It shows the remains of a fish that lived thousands of years ago. It was found in land that is now two thousand feet higher than the ocean. Was this land once under water? Yes, it was. The great Rocky Mountains that rise thousands of feet into the air were once under water. Some great forces pushed the land high into the air. Scientists do not know very much about these forces. They know even less about these forces than they know about volcanoes. Let us see what they have found out.



The earth is a great ball that is thought to be mostly rock. This rock is covered with a thin layer of soil in some places and water in other places. Sometimes one part of this big ball begins to push hard against another part. Scientists are trying to find out what force it is that causes this pushing.

What happens when one part of the earth-ball begins to push against another part? Suppose you take a sheet of paper and lay it flat on your desk. Place your hands on the ends of the paper and push toward the center. What happens to the paper?

It is hard to believe that these mountains were once level land that was pushed high up into the air.

It rises up in a ridge near the center. In much the same way mountain-ranges are formed when some parts of the earth push against other parts.

These great forces are changing the earth's surface all the time. But they make the changes very slowly. They took thousands of years to form the Rocky Mountains.

What is soil?

THE THINGS you have learned in this unit should help you tell what soil is. But the best way to find out about soil is to examine some of it. Get a handful of soil and examine it with a magnifying-glass. What do you see in the soil?

You can find out more about soil by getting samples from different places. Get samples from a gravel road, a woods, a clay pit or a place where the cellar of a house is being dug, and your garden. Examine these samples through a magnifying-glass and see how different they look. Take a little of each kind between your thumb and finger and see whether it feels gritty or smooth. What other characteristics can you find? How is each sample of soil different from the other samples? You can see from this that there are several different kinds of soils.

Soils that have much sand in them are called *sandy soils.* Do you know of places on the earth where the soil is very sandy?

Soils that have much clay in them are called *clay soils.* Perhaps you live in a place where there is clay soil. Clay may be yellow or red, or it may be other colors. Clay is made of rock that has been ground into a powder. Perhaps you have used clay to make marbles. You mixed the clay with water, rolled it into small balls, and dried the balls in the sun.

Another kind of soil is called *loam.* It is much darker than clay or sandy soil. Loam is a mixture of sand, clay, and decayed plant and animal material. When plants die, their dead roots remain in the ground. The part of the plant above ground falls to the earth. As time passes, these plant materials decay and become part of the soil. The bodies of dead animals also decay and become part of the soil.

Soils containing a large amount of decayed plant and animal materials are rich soils. This means that they contain materials which plants need to make them grow.

* * *

1. What is soil made of?
2. How are clay, sand, and loam different from each other?
3. Describe two ways in which rock is changed to soil.
4. Where would you expect to find rich loam, in a forest or in a desert? Why?

Questions to Answer

1. Describe the surface of the land near you and try to explain how it is changing. Did the ice-sheet cover the land where you live?

2. Make a list of the kinds of changes that take place on the surface of the earth. Then answer the following questions about each kind of change.

a) What causes the change?
b) Is the change fast or slow?
c) Is it taking place today?
d) Have you ever seen the change taking place?
e) When does the change take place?

3. What has the force of gravity to do with changing the surface of the earth?

4. These are some of the words you have studied in this unit. Explain what each means.

volcano
sandy soil
river bed
lava
erupt
glacier
loam
crater
clay soil
canyon
dune

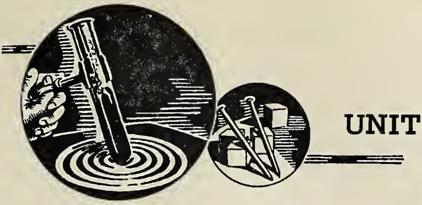
5. Explain this sentence: A grain of sand that is now far under the surface of the sea may sometime be blown about by the wind.

Things to Find Out

1. The next time you travel through the country, try to see some of the things that you have studied about in this unit.
2. Find out what happens when the Mississippi River keeps emptying its load of soil into the Gulf of Mexico.
3. Try to get a piece of lava and examine it. Read some stories about volcanoes and tell your class any new things you find out.
4. Look for pictures in books and magazines that show changes in the earth's surface. Write a paragraph explaining each picture and put your work on the bulletin-board.
5. Make a group of drawings that show different changes on the earth's surface. Explain your drawings to the class.
6. Find out what people do in some places to keep the soil from being washed away too fast.

7. Ask someone to tell your class about his visit to the Grand Canyon. Find some pictures of the canyon. Try to find the river in the pictures.

8. Collect some pictures of a glacier and explain what the glacier is doing to change the surface of the earth under it.



UNIT SIX

WHAT ARE THINGS MADE OF?

Did you ever find a piece of something and wonder what it was made of? Perhaps it was a stone with bits of white, yellow, and black materials. Or perhaps it was a piece of metal that was different from anything you had ever seen before. When you said to yourself, "I wonder what it is made of," you were asking a question that men and women began to ask many thousands of years ago.

These people saw many of the same things happening that you see. For example, they saw a big pile of wood burn up and leave only a small pile of gray ashes. They saw bright iron swords turn to a dull brown color when they rusted. Copper kettles changed from brown to green. Red, juicy meat that was good to eat on one day would change color and be spoiled a few days later. If they ate the spoiled meat, they found that it would often make them sick.

These people of long ago saw many other materials change from one thing into something very different. All these happenings made them wonder why materials changed and what they were made of.

A very long time ago a famous man decided that he knew what things were made of. He said, "Everything in the world is made of air, water, soil, and fire." Why do you suppose he thought that? He knew that living things need air and water to live and to grow. So he decided that many things must have air and water in them. He knew that plants grow out of the soil and that animals need plants for food. He thought that there must be some soil in all living things.

Fire was a mysterious thing that no one could understand. It seemed to come out of wood, cloth, and other materials when they burned. So the wise man decided that there must be fire in almost everything in the world, too.

This wise man gave a name to these four things—air, water, soil, and fire. He called them *elements*. "Everything in the world," he said, "is made of these four elements." But this famous man was wrong. And he never found out the right answer to the question, "What are things made of?" It was thousands of years later before people did find the right answer. You will find the answer in this unit of your book. A good way to begin studying this question is to examine some of the materials that you see and use every day.

How are materials different from each other?

SUPPOSE each one in your class brings two or three different kinds of materials to study. Here are some of the things that one science class brought: a piece of coal, a lump of wax, vinegar, water, buttons, wood, stone, rope, milk, nails, a tin can, maple syrup, salt, an apple, and some sugar. Henry even brought a bottle of carbon-dioxide gas. His father owned a drug-store, and he told Henry that carbon dioxide is used to make the "fizz" in soda-water. He took some of the gas from a big steel tank and put it into a bottle for Henry.

When you have your collection of materials ready, separate them into three groups: solids, liquids, and gases. Then examine each kind of material carefully to find out what it is like. Look for things that will help you describe the material to someone else. You may taste most of the materials, feel them, look at them, heat them, smell them, and squeeze them. You may try to pull them apart and try to bend them. But you must be careful not to heat and taste materials unless you know what they are. The material might explode, or you might be poisoned.

While you are examining these things, write on the board or on a piece of paper the different words you would use to tell what the materials are like.

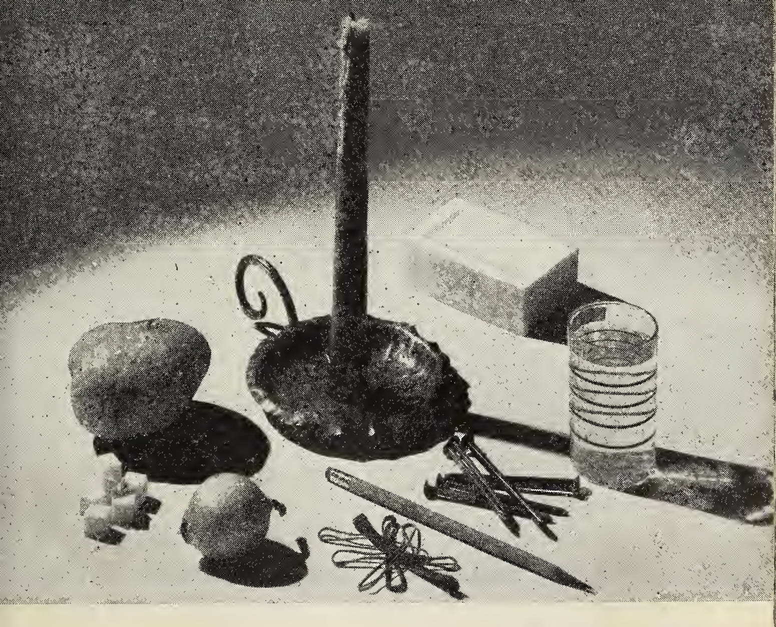
When you get through, you should have a list something like the following one.

Hard
Soft
Elastic
Brittle
Sticky
Watery
Colorless
White
Black
Brown
Sour
Sweet
Rough
Smooth
Easy to melt
Hard to melt
Can be stretched
Can be bent
Can be squeezed together

Write this sentence at the top of your list: "These are some characteristics of materials."

Do you know what the word *characteristics* means? When we want to describe a person, we tell what his characteristics are. Perhaps you have blue eyes, dark brown hair, freckles on your face, and a little scar on your finger where you cut it last month. These are some of your characteristics. They describe you. Other people know who you are by these characteristics. Every kind of material has characteristics of its own. These characteristics tell us what kind of material it is.

The way we use materials depends upon their characteristics. What characteristics of glass make it good for windows? You can probably answer this question very easily. First of all, you know that glass is transparent, that is, we can see through it. Then, too, glass will not soak up water. If it did soak up water, our windows would become



What materials do you see in the picture? What characteristics does each material have?

soaking wet every time it rained. Glass is also good for windows because it is quite strong.

The boys and girls in Miss Bryan's room were examining all the materials they had brought to class. They wanted to find the important characteristics of each material. They stretched some rubber bands and found that rubber is *elastic*. They squeezed a piece of cotton and a sponge and saw that they could make these take up less room. They found that cotton and sponges could be *compressed*.

As the boys and girls were finding the characteristics of the different things, something funny happened. Jane saw some brown liquid in a jar. She asked Miss Bryan if it would be safe to taste it. When Jane was allowed to taste it, she swallowed a spoonful of it. You should have seen her face! The liquid was vinegar, and Jane learned one of its chief characteristics. It is sour.

The boys and girls knew that it was dangerous to taste a liquid if they did not know what it was. "The liquid might be poisonous," said Robert.

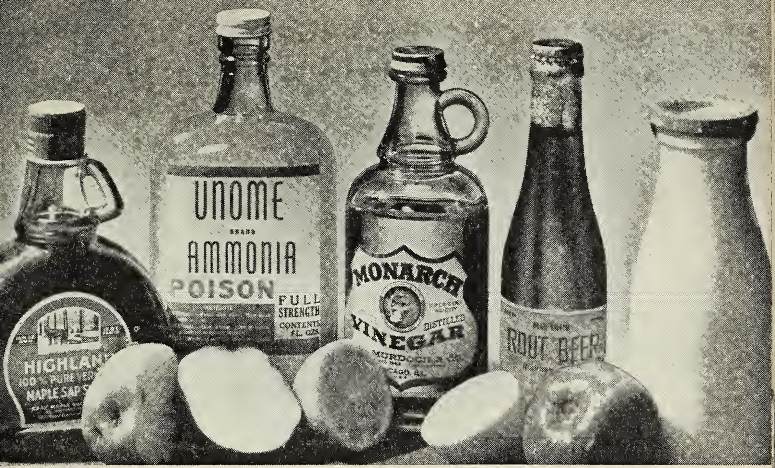
Then the boys and girls asked Miss Bryan if there was a safe way to find out if anything is sour.

"Yes, there is a safe way," said Miss Bryan. "Everything that is sour contains *acid*. I'll show you how a scientist tests a material to see whether it contains acid."

She got a strip of some material called *litmus-paper*. This litmus-paper was blue in color. She put one end of the litmus-paper in a small amount of vinegar. When she took it out, the end that had been in the vinegar had turned red.

"A scientist knows that anything containing acid will turn blue litmus paper red," Miss Bryan said.

Of course the boys and girls wanted to test some other things. They cut a lemon in half and put one end of the blue litmus-paper against the cut surface of the lemon. The lemon turned the paper



How can you find out which of the materials shown in the picture have acid in them?

red. This proved that the lemon had acid in it, too. Miss Bryan then mixed some baking-soda in water. When the blue litmus paper was put in this, it did not turn red. Does baking-soda have acid in it?

* * *

1. What characteristic of iron would make it a poor material for windows?

2. What characteristic of iron makes it a good material for use in stoves?

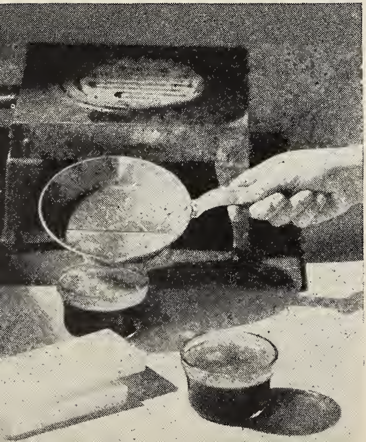
3. Tell some characteristics of wood that make it a good material for furniture.

4. Compare the characteristics of cellophane and tissue-paper. Why is cellophane better than tissue-paper for wrapping food?

How can we change the characteristics of materials?

SUPPOSE you take two or three of the materials that you have brought to school and try to think of ways in which you can change some of their characteristics. For example, how could you change water? Right away you may think of freezing it and of boiling it. When you freeze it, it changes from a liquid to a solid. When you boil it, it changes from a liquid to a gas. Solid blocks of wax like those in the picture can be changed to liquid wax by heating them. A piece of lead will change to a liquid if you make it hot enough.

But what happens to the liquid wax when it is poured on to the cool jelly? And what happens to melted lead when it cools? Did the water, the wax, or the lead change into a new material when it was heated or cooled? No, it didn't. The lead is still lead, the wax is wax, and the water is water, no matter whether they are solid, liquid, or gas.



You know another way to change materials. Some materials can be dissolved in liquids. You have dissolved sugar in water when you were making lemon-

ade, and probably you have dissolved salt in water, too. If you tasted the water, you could tell that the salt and the sugar had not been changed into something else. They were still the same materials, even though they had been dissolved in water.

Now let us do an experiment to show a very different way in which we can change materials. Take a test-tube and fill it about one-fourth full of sugar. If you do not have a test-tube, use a tin lid from a jar or can. Heat the sugar for several minutes. Watch closely to see what happens. The sugar is changing from a white material to a black material.

The hard, shiny material in the new can has changed to brown, crumbly rust.

There is also a white gas coming from the sugar, and you can see some drops of a brown liquid on the inside of the test-tube. What do you think has happened?

You have changed the sugar into something entirely different. The material left in the test-tube does not have any of the characteristics of sugar, because it is no longer sugar. If you cool this black material and taste it, you will find that it is not sweet.

When Miss Bryan's class tried this experiment, Harry said, "I was surprised when I tasted that black stuff. I thought it would be sweet, but it didn't taste at all like sugar."

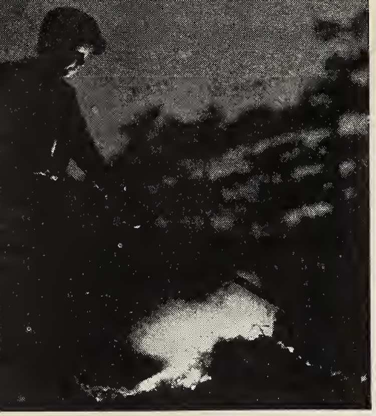
When you dissolve sugar in water, you do not change it into anything else. But when you heat sugar, you change it into something different.

You have often seen other changes that make new materials. You have seen bright, shining iron or steel changed to a brown, rusty material. Perhaps you have lost a pocket-knife and have found it out in the yard several days later. You could easily rub off some of the brown rust with your fingers. Or perhaps you have seen an old can that has been outdoors for a year or more. You know that such a can is full of holes and that it is soft and crumbly. We say that the can has rusted. A new material has been made out of the material of the can.

The changes that are made when sugar is heated and when iron rusts are very different from the changes that happen when you heat wax or water or lead or when you dissolve sugar in water. The iron changes into something else. And the sugar becomes something different. New kinds of materials are made. These new materials are different from the old materials. This kind of change is called a *chemical change.* It is a chemical change because the materials have changed to different kinds of materials.

You have seen chemical changes going on around you ever since you were old enough to notice them. In autumn when leaves turn from green to red, yellow, orange, and brown, a chemical change has taken place in the leaves. Different materials have been made inside the leaves. When you find a piece of soft, brown, crumbly, decayed wood, you are looking at something that has been made by a chemical change. The hard yellow or white wood that could have been made into a beautiful piece of furniture has been changed into something else.

Every time you light a fire, you start a chemical change. Burn a small splinter of wood in a metal pan. Be very careful to see that there is



Does a chemical change take place when you burn a pile of leaves? Why do you think so?

nothing near the pan which can catch fire. Watch the piece of wood change. After part of the splinter has burned, put out the blaze. What is left from the burned part? Where has the rest of the wood gone? What color is the portion of the stick that was partly burned?

You can see that a chemical change has taken place, because the ashes and the black material are very different from the piece of wood. A big piece of hard, black coal changes into a little pile of soft, gray ashes when it burns. The ashes are very different from the coal that burned.

Chemical changes are taking place inside your body all the time. Your body is really a chemical factory. Some of the food that you have eaten today is being changed into part of you. This is a wonderful change. Take a small piece of bread into your mouth and chew it for a long time. How does the taste of the bread change? If you hold it in your mouth long enough, the starch in the bread will change into something that tastes sweet. This is one of the chemical changes that prepares the food for use in the body. Every day meat, potatoes, milk, fruit, eggs, and other foods are being changed into blood, muscles, bone, and teeth. You could not live if the food you ate were not changed into part of you.

* * *

1. When you peel potatoes, do you make a chemical change? Explain your answer.
2. Why is burning a piece of wood a different kind of change from melting a piece of iron?
3. What do chemical changes do to materials?
4. How are the characteristics of wood different from the characteristics of wood ashes?
5. After a chemical change has turned the green leaves to their autumn colors, what characteristics are still the same? What characteristics are different? Does a chemical change always make all the characteristics of an object different?

What are elements?

WHAT do you think happened to the sugar when you heated it? And what is the brown material that you rub from a rusty skate? Before you can answer these questions, or understand the other chemical changes that take place around you, you will have to know something about *elements*.

You remember that a famous man of long ago thought that everything in the world was made of four elements: air, water, fire, and soil. But scientists now know that there are ninety-two different elements instead of just four. And they also know that air, water, fire, and soil are not elements at all. All the different things in the world are made of these ninety-two elements.

You have seen some of these elements. You have seen iron, gold, copper, lead, silver, nickel. Perhaps you have also seen mercury, or quicksilver, and sulphur. These, too, are elements. You will never see some of the elements, because they are colorless gases. The oxygen in the air is one of these colorless elements. The air also contains nitrogen and several other colorless gases that are elements.

You probably will never see some of the other elements, because they are so scarce. Some elements are so very rare that you would never find them unless you went to some great science laboratory to see them.

Collect as many different elements as you can find. Label them and put them on a shelf for an exhibit. One science class was able to find eleven elements. They had lead, iron, copper, gold, silver, nickel, aluminum, and sulphur. To get two other elements, zinc and carbon, one of the boys took an old dry cell apart. The thin sheet of gray metal

Each one of these objects has in it a large amount of the element printed under it.

around the cell was zinc. The black rod in the middle of the cell was carbon. One boy brought an electric-light bulb. His father had told him that the wire inside was made of an element called tungsten.

Do you know why we call these materials elements? If you look in the dictionary, you will find that "element" means the simplest kind of material. Iron, silver, copper, lead, and the other elements are the simplest materials in the world. You can take one of these elements, such as iron, and crush it, grind it into the finest kind of powder, heat it, or dissolve it in liquids. But you cannot find any material in it except iron. For this reason we call it an element. An element is made only of itself, not of two or more materials put together. Iron is made only of iron; gold is made only of gold.

All the things in the world are made of these ninety-two elements. The next time anyone asks you the question, "What is it made of?" you may be sure you are right if you say, "It is made of elements." Some materials, like water, carbon dioxide, and salt, are made of only two elements that are united. Others, like sugar, baking-soda, and gasoline, are made of more than two elements put together.

* * *

1. What is an element?
2. Why can some of the elements not be seen?
3. How many elements are known to scientists?

How are elements joined together?

THINK carefully again about what happened to the sugar when you heated it. A black material stayed in the test-tube. A white gas went up out of the test-tube, and drops of brown liquid appeared on the inside of the test-tube. Do you think that sugar is an element? It looks as if the sugar has been changed into several other materials.

That is exactly what has happened. The black material left in the test-tube was the element carbon. The brown liquid that appeared on the inside of the test-tube and the white gas that you saw contain three elements—carbon, hydrogen, and oxygen. So you see that sugar is a material that can be changed to simpler materials. Sugar is a *compound.* It is made of three elements: carbon, hydrogen, and oxygen. A compound is a material made of different elements joined together.

When the boys and girls in Miss Bryan's room were talking about this, Nancy said, "I made some carbon this morning. I was helping my mother get breakfast, and I forgot the toast in the oven. When I looked at it, the toast had changed to carbon."

Isn't it strange that two colorless gases and a black solid can make white, sweet sugar? But that is just what happens when chemical changes take place. We get an entirely different material. And the new material has different characteristics. Water, for example, is made of two elements—hydrogen and oxygen. These elements are colorless gases. When hydrogen and oxygen are joined together in just the right way, they make water.

There are only ninety-two elements known to scientists, but these elements can be joined together or *united,* to make many different kinds of materials.

Have the sulphur and iron united to make a new material? Why do you think so?

Of course no element can be united with every other element, but most of the elements can be united with several other elements to make compounds. Some compounds are made of only two elements. Others may contain several elements.

Whenever compounds are made, the elements do not just *mix* with each other. They unite, or join with each other, to make the compound. For example, take some powdered sulphur and some powdered iron and shake the two elements together in a test-tube. You will not make a compound. Pour the mixture out on a table and hold a magnet on the mixture. The fine pieces of iron will stick to the magnet. The sulphur will be left on the table. Put the mixture back in the test-tube and pour water in the test-tube. Still you have not made a compound. The sulphur rises to the top of the water, and the iron sinks to the bottom. The two elements have not been united with each other. They have only been mixed with each other.

Let us see if we can make these two elements unite. Put exactly twice as much sulphur as iron into a test-tube and mix them. Hold the test-tube over a flame and heat the two elements until they are very hot and seem to be united. Cool the material and remove it from the test-tube. You may have to break the test-tube to get the material out.

Test it with the magnet. Does the magnet still pick up the iron? Put the material in water. Does it sink? The iron and sulphur have united to form a compound that is different from either iron or sulphur; so the magnet can no longer attract the material. This material is no longer iron.

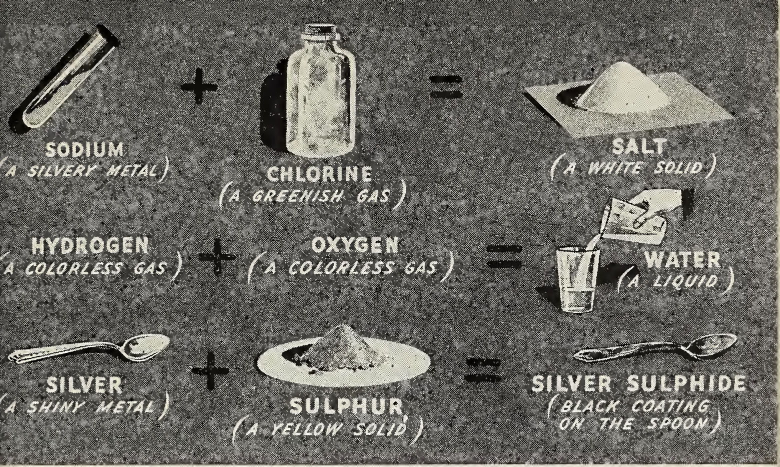
Now let us learn about some other compounds. The element iron is a hard, silver-gray material. When it rusts, it joins, or unites, with some oxygen from the air and changes to a soft, crumbly, brown

material. When someone asks you what iron rust is, you can tell him that it is a compound made of iron and oxygen. Bring a piece of rusty iron to school and examine it. Notice how soft the rusted part is.

Did you ever see copper that had been outdoors for a long time? It had probably turned a dull, brownish color. If you scraped the dull material off with a knife, you found the shiny copper underneath. That outer covering was a material made of copper and oxygen. These two elements had joined to make a material that was not like copper. It was not like oxygen, either. It was a compound of copper and oxygen.

Every day you use a compound that is made of two very dangerous elements! This compound is white. You probably use it on your egg at breakfast. Your mother uses it in cooking almost everything. It is salt! Salt is made of two elements. One of these elements is a bright, silvery, soft metal. If you put a piece of it on your tongue, it would burn your tongue badly. The other element is a greenish-colored gas that has a very bad smell. It is poisonous!

But when these two elements are joined together by a chemical change, an entirely different material is made. This new material is not poisonous; it will not burn your tongue; and it does not have a



This picture shows some elements that unite to make new materials. What changes have taken place?

bad smell. It really helps the taste of your food so much that you use it every day. The chemical change has made a compound that is very different from the two elements that are in it.

If your house is painted white, it is probably covered with a compound made of the two elements, zinc and oxygen. When iron and oxygen join, they make the brown material that we call iron rust. But when zinc and oxygen join, they make a compound that is a white powder. This white powder is mixed with oil to make white paint.

Did you ever hear of a kind of paint called red lead? Perhaps you have seen men painting iron bridges or other iron with this bright red paint. It is made of a compound of lead and oxygen.

Everything in the world is made of elements and compounds; so of course your body is made of elements and compounds. Scientists have figured out that there is enough iron in a person's body to make a good-sized nail. There is enough phosphorus in your body to make a match. Of course, you know that the iron in your body is not solid iron like a nail, and you know that the phosphorus will not blaze up like a match.

Your bones have in them another element called calcium. Milk is good food for making bone because it has much calcium in it. Your body is made up of many other elements and compounds. You will learn about some of these materials later in your science study.

* * * *

1. Name an element in the air that you use in your body. Find out the names of some of the other elements that are mixed together in the air.

2. Tell two important things that you know about elements.

3. How are compounds different from elements?

4. Mix salt and sugar. Did you make a compound, or are they just mixed together? Explain your answer.

5. How many of the chemical changes mentioned in these pages have you seen?

6. You have learned that salt is made of two elements. One of these elements burns; the other is poisonous. Why does not salt burn you or poison you?

7. Do you think that a chemical change takes place in milk when it sours? Why? Give reasons for your answer by listing the characteristics of sweet milk and of sour milk.

How do we use chemical changes?

YOU HAVE learned that chemical changes are happening all around you and that they are very important. All over the world today scientists are studying the things that are in the earth and on the earth. They are finding ways of putting elements and compounds together and ways of taking them apart. They put elements and compounds together to make many kinds of new materials. These new materials are different from the elements and compounds that were used to make them. The new materials have characteristics that make them more useful to us.

For example, the window glass that is letting light into your school-room was made mainly from sand. It is easy to see that sand must be changed before it can be made into glass. You cannot see through sand, but you can see through glass. Scientists have found out how to make glass by adding some

A mixture of sand and other materials is going into the furnace to make glass. In what ways is this material changed before it can be used in windows?

other materials to sand. When this mixture is heated to a very high temperature, it melts and changes into a new material—glass. The liquid glass can be poured out on a table and rolled into a flat sheet. When this sheet cools, it can be polished to make it smooth and clear. Then it can be cut into pieces and used for glass in windows. This is only one of the many uses of chemical changes.

The paper in this book was made by using chemical changes. The material from which this page was made was once part of a tree. The tree was cut and the wood was ground up into a pulp. Materials were then added to the pulp, and chemical changes took place. These changes made the material for this paper. You could never make a book from the wood as it came from the tree. But after the chemical changes took place, a new material was made. It has characteristics that make it good for many uses. This new material is the paper that is used for books, newspapers, magazines, and many other things.

Your mother uses chemical changes at home every day, too. When she bakes a cake, she often uses baking-powder, which brings about a chemical change that makes the cake light. If she burns gas, wood, coal, or oil in her stove, she is using the chemical change of burning to bake the cake. If she lets milk sour to use in cooking, she is using a chemical change.

You know that a chemical change takes place when sweet milk turns sour. The taste of the milk changes from sweet to sour. Would you like to try an experiment to see if you can make another chemical change take place in the milk? Put a strip of blue litmus-paper in some sour milk. Does the sour milk turn the paper red? If the paper turns red, you know that the material has acid in it. Now stir a spoonful of baking-soda into the sour

Here is a picture of the film used for the picture on page 198. Chemical changes were used to make the film, to take the picture, and to make prints from the film.

milk. Put a strip of litmus-paper in the mixture. This time the blue litmus-paper does not change color. Taste the milk. It does not taste sour now, does it? When you put in the baking-soda, you caused another chemical change.

It was funny to watch the expression on Ellen's face as she tried this experiment. When she began, she knew the milk was sour because she had tasted it. She could hardly believe what happened after the baking soda had been stirred into the sour milk. The children laughed as she tasted it the second time to make sure that the sour taste had really been changed by the soda.

Here is another example of a chemical change. If your mother is wearing a dress made of rayon, she is wearing cloth that was probably made from wood! Chemical changes certainly took place before cloth could be made from wood.

* * *

Suppose you take some other common thing in your school-room or in your home and try to find out what it is made of and how it is made. Then report to your class what you have found out.

How can we stop harmful chemical changes?

PERHAPS you think that all chemical changes are good for man. But if you think carefully, you may find that some of them are harmful.

Can you think of some chemical changes that you may want to stop? You probably will think of rusting. Bridges, automobiles, skates, bicycles, nails, and other things made of iron and steel would soon be useless if something were not done to keep them from rusting. Do you know how to keep them from rusting? If you think carefully, you will say that we must keep oxygen away from them. But how can we keep oxygen away from them? Just

How is a harmful chemical change being stopped here? When you have studied page 228, tell one reason why water can put out this fire.

cover the iron and steel with something that will keep the oxygen in the air away from them. Paint is used to cover these metals. Steel tools are often covered with grease to keep oxygen away from the metal.

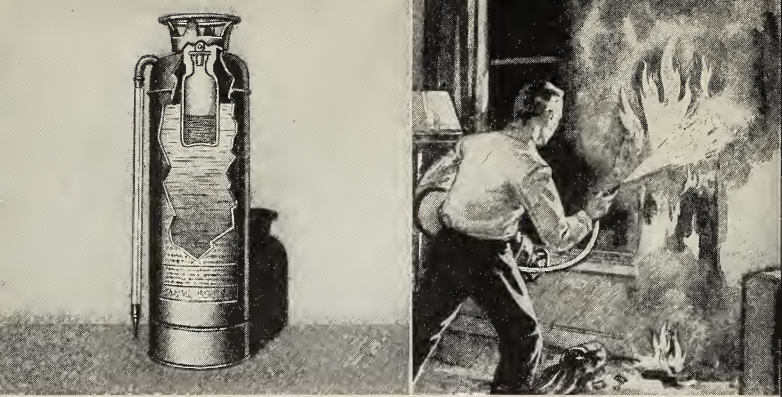
You have already learned about another chemical change that sometimes does great harm to man. It destroys millions of dollars' worth of houses, forests, furniture, and other things every year. This chemical change is fire. Men have learned how to stop this chemical change, too. Try this experiment, and it will help you see what kind of chemical change takes place when things burn.

Set a short, lighted candle in a shallow dish of water. Place a milk bottle over the lighted candle and notice the height of the water in the milk bottle. As the candle burns, what happens to this water? After a short time what happens to the candle flame? It soon goes out because there is no more oxygen inside the bottle.

Why does the water rise in the bottle? The water rises because part of the air in the bottle has been used up. The oxygen in the air has been used up by the burning candle. The other gases are still in the bottle. No material will burn unless it can join with oxygen. If you keep oxygen away from it, the burning must stop.

Do you know of ways to keep oxygen from fires? Here is an experiment that will show you one way to keep oxygen from a fire. Light a match and lay it on a tin plate. Cover the burning part of the match with sand. Why does the match stop burning?

Sometimes men shovel dirt on a fire to put it out. The dirt covers the burning material and keeps oxygen away. Then the fire goes out. If the clothing of one of the men should catch on fire, this fire also could be put out by keeping oxygen away. A blanket or heavy coat quickly wrapped around the man would keep the oxygen away and put out the fire.



The first picture shows the inside of a fire-extinguisher, and the second one shows how it is used.

One of the reasons that water can put out a fire is that it keeps out the oxygen. It covers the burning material and keeps the oxygen from uniting with it. Probably you have fire-extinguishers in your school. Many of them contain materials that can make carbon-dioxide gas. This gas is so heavy that it settles down over the burning material. The covering of carbon-dioxide gas keeps the oxygen away from the fire, and the fire goes out. The carbon-dioxide gas also makes a pressure inside the extinguisher and forces water out on the fire.

Here is an interesting experiment for you to try. Put some baking soda in a test-tube and pour some vinegar on it. Then hold a lighted match over the test-tube. Why does the match stop burning? Why do you think you have made a simple fire-extinguisher?

Another chemical change that we usually do not want is the souring of milk. Covering the milk will not stop it from changing, but keeping it cold will do so for several days. So we put milk in the ice-box to keep the chemical change from taking place quickly. The decaying of meats and vegetables is also a chemical change that we do not like to have happen. So we put these foods in the ice-box to keep them from changing.

Try this experiment and see what it tells you. Put some nails in a dish and keep them damp by sprinkling them with water. Put some other nails in a dry dish. Examine the nails a few days later. Which ones are rusty? Iron rusts more quickly when it is damp.

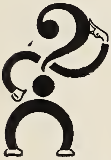
Which decays more quickly—a piece of wood out-of-doors in the rain, or a piece of wood inside a house? Wood, leather, and other materials decay more rapidly when they are wet. We can stop some chemical changes by keeping these materials dry.

Did you ever have some of your clothing fade? The colors changed from bright to dull. If you have wall-paper on your walls at home, look behind some picture that has been hanging in the same place for a long time. Perhaps you have already done this. Is the paper behind the picture different from the rest of the paper? What do you think makes cloth and paper and ink change color? Many materials fade because they are in the light. Sunlight makes chemical changes in the material that was used to color the cloth or the paper.

* * *

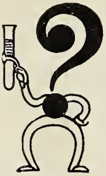
1. Tell three ways to keep materials from changing into other materials.
2. What happens when cloth fades?
3. Have you ever done anything to stop chemical change? Tell what you did.

Questions to Think About



1. Name two things in your school-room that have been made by a chemical change. Name one thing that your mother uses that is made by a chemical change.
2. Why do men paint bridges?
3. Why are chemical changes so important to us?
4. Name two chemical changes that you think are harmful. Explain why you think they are harmful.
5. Long ago, people did not know about elements and compounds. Could they explain burning, rusting, and the souring of milk?
6. Suppose you heated a material in a test-tube and found that it did not change. Would you be sure then that the material was an element? Think carefully before you answer.
7. Do you think that there are more compounds in the world than elements? Explain your answer.

Things to Find Out



1. Find out more about elements. Perhaps you may ask some high-school science teacher to talk to your class about some of the elements that you have never seen.

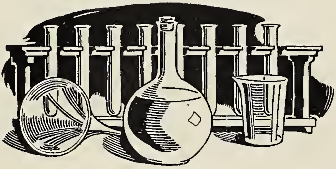
2. Read about some scientist who discovered one of the elements.

3. Visit a photographer's shop and ask him to show you how he uses chemical changes in making pictures.

4. Make a list of rules for putting out fires.

5. Find out how your school fire-extinguisher works.

6. Make a list of rules for safety in experimenting. Post them on the bulletin-board.



PEP

UNIT SEVEN

HOW DO LIVING THINGS GET FOOD?

"I'M HUNGRY." How many times have you said that to your mother in the last week? Everyone gets hungry, and everyone spends many hours of his life eating. If you live to be seventy years old, how much of your life do you think you will spend eating food? A person who lives to be seventy years old spends about six years of his life eating. If it takes you about two hours a day to eat your meals, you spend about one month each year eating.

And how many people do you think it takes to get our food for us? Well, more than three million people work on the farms of our country. Thousands more work in factories where food is canned, baked, and made ready for us in other ways.

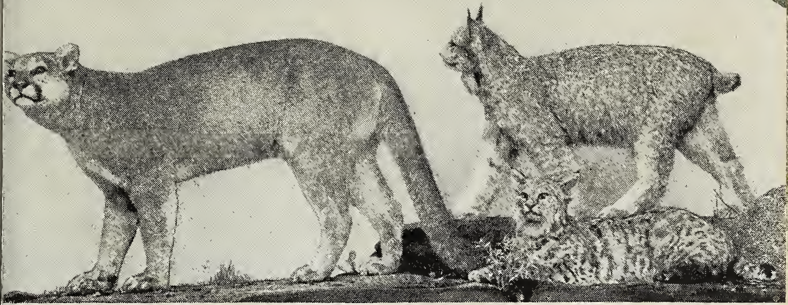
But men and women and boys and girls are not the only living things that spend so much time getting and eating food. Every plant and animal spends most of its life getting food. In Unit One of this book you read about the millions of insects that birds eat. Birds spend many hours each day catching all these insects. Think of the animals that you have seen in the woods and fields. Almost all of the time they are either hunting for food, eating food, or just resting. Cows, horses, and sheep out in the fields seem to eat, eat, eat all day long. Elephants need so much food that they spend many hours of every day eating.

How do animals get food?

Do you have any pets at home? Suppose you bring one of your pets to school. The members of one science class were able to bring to school a cat, a dog, a rabbit, a guinea-pig, a toad, a goldfish, a canary, and a chicken. Feed the animals that are brought to class and watch them eat. Can you find out how each of these animals gets food, and why it gets food the way it does?

Perhaps you have seen a cat catch a mouse. Why can a cat catch mice better than a dog can catch them? Let us see. Cats have sharp, hooked claws. With these claws they can seize a mouse and keep it from getting away. Cats' eyes are made so that they can see well at night when the mice run around the quiet house. Cats are small. Their feet have pads on them; so they can move silently. All these things help them catch mice for food.

Dogs have short, blunt claws that are not very helpful in holding the things they catch. Dogs cannot move as quietly as cats, and they cannot see as well at night. But dogs have legs that carry them

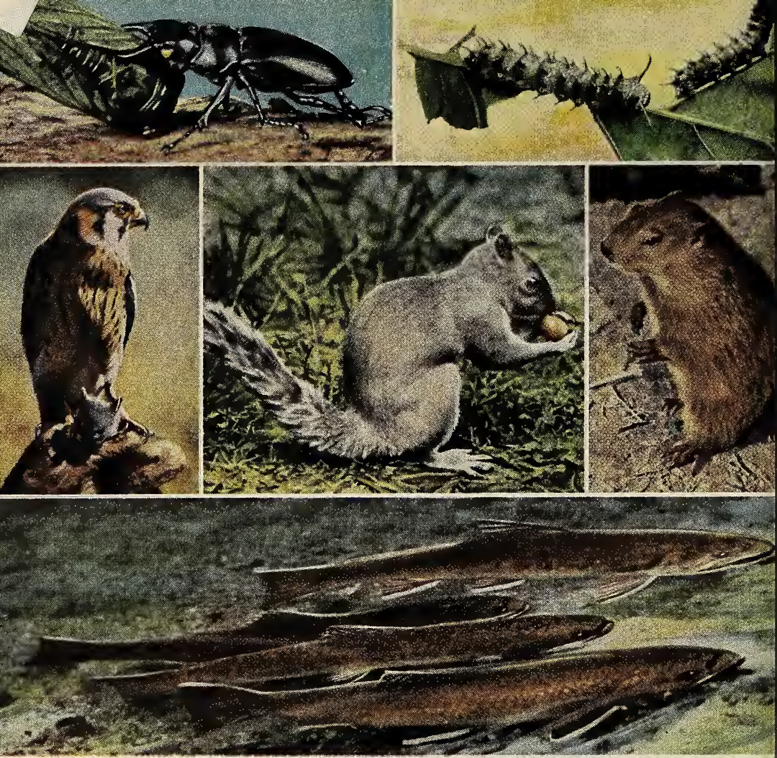


Here are a mountain-lion, a lynx, and a bob-cat. All of these animals have much the same structure as house-cats. They have sharp teeth, sharp and powerful claws, softly padded feet, and eyes that can see well at night. They can climb trees.

over the ground swiftly. They can chase and capture rabbits, while cats find it hard to catch a rabbit.

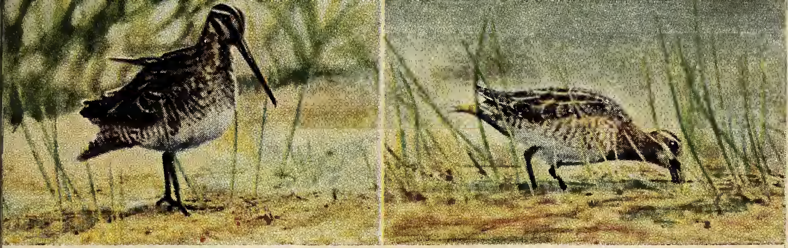
Do you see now why animals get their food in different ways? A cat is a better mouse-catcher than a dog because the cat's body is different from the dog's body. Cats and dogs, you remember, are mammals. Both are covered with fur or hair, feed their young with milk, and breathe with lungs. But the structure of a cat's body is different in some ways from the structure of a dog's body. The kind of food an animal uses depends upon the structure of the animal.

You will find it most interesting to watch animals getting food. If you watch sparrows, you will see that they cannot capture and



How is the structure of each of these animals helpful in getting food?

eat the kinds of food that eagles and owls eat. Eagles and owls have sharp, powerful claws and sharp, hooked beaks. They have strong wings and can swoop down and seize rabbits, snakes, woodchucks, and even other birds. With their strong claws they can hold these animals, and with their beaks they

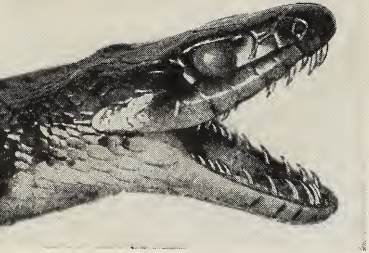


This snipe pushes its long bill down into the soft mud to get insects and worms.

can tear them into pieces and eat them. The sparrow can pick up only small particles of food such as seeds and small insects.

If you watch a woodpecker on the side of a tree, you will find that he has feet with claws that can hold him firmly to the side of a tree. Then his long, sharp bill chisels holes in the tree, and his pointed tongue spears the insects that are in the tree. Can you imagine a duck getting food in this way? Ducks could never get food the way woodpeckers do because the structure of the duck is different from the structure of the woodpecker. A duck cannot hold to the side of a tree. But its webbed feet help it to swim in water and to walk in muddy places to find food.

Of course you have seen rabbits and squirrels eating. They both have sharp teeth, but rabbits cannot hold nuts in their paws. Have you ever watched a toad catch flies with his sticky tongue? The toad can quickly flip out his tongue. It is fastened at the front of his mouth.

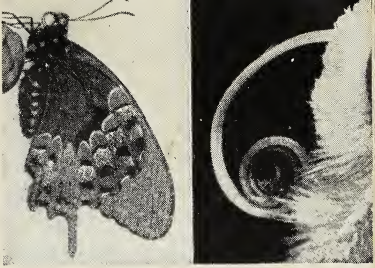


What helps this snake hold the animals that it catches for food?

Snakes have no arms or legs or wings to help them capture food, but they can slide silently over the ground and catch animals by surprise. Then, too, the structure of the snake's mouth helps it to hold food. A snake's teeth slant backward. When a snake gets those slanting teeth into an animal, it is almost impossible for the victim to squirm loose.

Another thing about the snake's structure helps it to get food. The snake's jaws are not fastened tightly together at the back the way yours are. They are fastened together with muscles that can stretch. This makes it possible for the snake to swallow large animals. When the snake eats, it moves first one jaw forward and then the other jaw forward. These movements slowly force the food into the snake's body.

The ant-eater has one of the strangest ways of getting food. This animal, which you see in the picture on this page, has no jaws. It cannot open its mouth. But the ant-eater has a long, sticky tongue which it can thrust out of its mouth. When it finds some ants, it sticks its tongue among them,



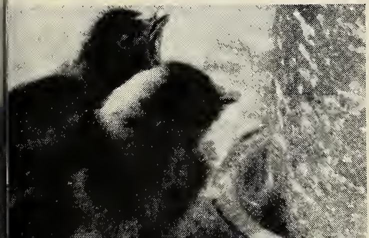
The picture at the right shows a butterfly's head as it would look through a magnifying-glass.

and the ants are caught on the sticky tongue. Then the ant-eater quickly pulls its tongue back into its mouth and eats the ants.

Many butterflies and moths suck their food in through a tube. They keep this tube coiled up under their heads like a watch spring when they are not using it. You can see this tube in the picture at the top of the page. Humming-birds suck the juices from flowers through long bills.

Horses and cows suck water into their mouths, but dogs and cats lap water and milk with their thin tongues. Chickens can neither suck water nor lap it up. They take some water into their bills and then lift their heads up to make the water run down their throats. Notice the little chicks drinking in the picture below.

You can probably think of many other interesting things to tell about how animals get food. It would take many, many books to tell all there is to know about this. Almost every part of an animal's body helps the animal to get food. The kind of food an animal eats depends on the animal's structure, that is,



the parts of the animal's body and the way those parts are put together. Robins, for example, are not made so that they can capture and eat mice. The way an animal catches its food and the way it eats depend on its structure, too.

1. Sheep can get food in a pasture where the grass is too short for cows to eat. Can you find out why this is true?

2. What do you mean by the *structure* of an animal?

3. Choose one animal and show how its structure helps it get food.

4. How does the structure of a cat help it catch birds?

5. How does the structure of a mosquito help it get food?

6. Make a chart like this. See how many animals you can add to it.

Animal	Food	Structure for Getting Food	Structure for Eating
Cat	Mice Milk Birds	Long, sharp claws Padded feet Eyes to see at night	Sharp teeth Claws for holding Rough, thin tongue for lapping

How do green plants get food materials?

YOU HAVE read how animals spend most of their time finding food and eating. Do you know how green plants get food? Animals can run, bite, swim, see, fly, and do many other things to get food. Plants have to stay where they are growing. They cannot move about, and they cannot eat other plants and animals for food. But green plants can make their own food. There are only two places where green land plants can get the materials they need for making food. Do you know where they are? One place is the soil. The other place is the air.

The parts of the plant work together to make food.

But plants cannot eat soil and air any more than you can. They must take materials from the soil and the air and make food out of them. When we want to discover how green plants get food, we have to study their structure. The way they get food depends upon their structure, just as the way an animal gets food depends upon its structure.

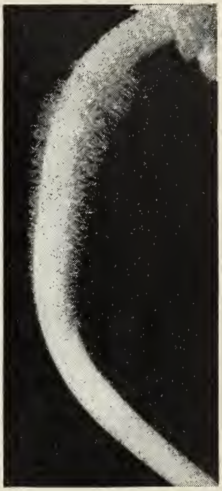
Green plants are really chemical factories. They can make things that nothing else in the world can make. Even the most wonderful chemical laboratories in the world cannot do what the green plant does. Plants make food by chemical change, and the chemical change takes place in the green leaf. The roots and stems are other parts that work together to help the leaf, but the leaf really makes most of the food for the plant.

Now let us see how the leaf factory gets the materials it needs. Every factory, you know, must have materials with which to make things.

You already know that plants must have water to stay alive. You also know that they get this water from the soil through their roots. Roots spread out in every direction so that they can get enough water for the plant. Plants that live in very dry regions may need to send their roots far down into the ground before they are able to get any water at all.

If you could look through the dark earth, you would be surprised to see how the roots work at getting water. Some plants have one main root, with several smaller roots branching out from it. Carrots have roots like this. Other plants have no main root; their roots are like small branches that spread out in every direction. If you dig up grass, you will find roots of this kind.

The large main roots do not take in the water. The smaller roots that branch off from them do not take in water, either. But on these smaller roots there are very tiny rootlets. They are as small as hairs and are called *root-hairs.* There are hundreds of these root-hairs on one small root. It is their work to get water. Around the outside of a root-hair there is a thin covering. Water from the ground soaks into the plant through this thin covering, or wall, of the root-hair.



Here are root-hairs on a root of a corn plant.

If you want to see how root-hairs look, you can easily see them by sprouting a few seeds. Place a dozen lima beans or several radish seeds on some moist blotting-paper in a shallow dish. Keep the dish covered with glass so that the seeds will stay damp. Do not cover the seeds with water, but keep the blotting-paper moist.

After the seeds have sprouted, take a magnifying-glass and examine one of the roots. You will be able to see many tiny root-hairs. Sometimes you can see them without a magnifying-glass, because there are so many of them. Once when some boys and girls saw the fuzzy root-hairs on seeds that they had sprouted, they thought the plants were moldy and threw them away! They did not know that the fuzz which looked like mold was really thousands of root-hairs!

When water from the soil goes into the root-hairs of a plant, some very important materials enter with the water. They are minerals from the soil. These minerals have dissolved in the water that soaks into the ground from rain and melted snow. You know the names of some of these minerals found in the soil. You have experimented with iron and sulphur, and you may have heard of calcium and phosphorus. Some of the minerals in the soil are made of these elements.

Of course the iron that the water takes from the soil is not in lumps like iron that you have seen. The other minerals are not solid, either. You cannot see the minerals in the water. Do you know why? You cannot see them any more than you can see sugar or salt when it is dissolved in water. All water in the ground has some kinds of minerals in it. Minerals are almost everywhere in the soil. Did you ever taste water that came out of the ground from a spring? Water from springs often does not taste like other drinking water. The strange taste may be caused by minerals. You cannot see the minerals, but you know they are there because you can taste them. Minerals are some of the materials that the green-plant factory needs for food-making.

* * *

1. Why must minerals be dissolved in water before a plant can use them?

2. What parts of a root take in water?

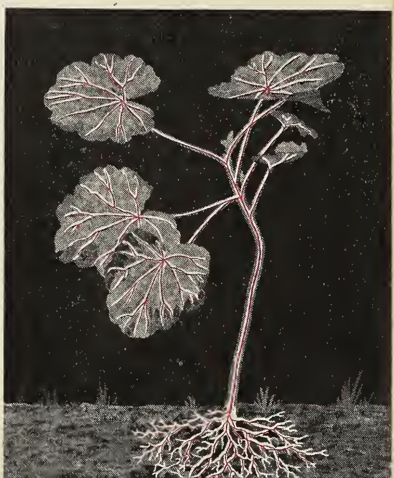
3. Which kind of plant needs to have the longer root—a desert plant or a swamp plant? Give reasons for your answer.

4. What will happen if you cut off the root-hairs of a plant? Try an experiment to see if your answer is right.

How do water and air get to the leaves?

AFTER the water soaks into the roots of the plant, it must get up to the leaf before it can be used in the leaf factory. How do you suppose the water gets to the leaves? The stem of the plant is so made that it can carry water. The water travels through tiny pipes, or tubes, inside the roots and

Where are the water tubes in this plant?

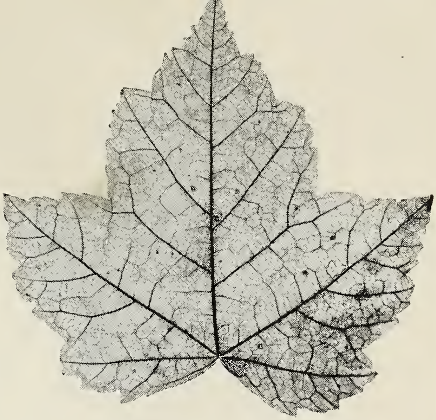


stems. An easy way to see these pipes, or tubes, in a stem is to try this experiment. Get a stalk of celery with several leaves on it. Cut off about an inch of the bottom of the stalk. Fill a drinking-glass with water and add some red ink to the water to color it. Place the celery in the glass of colored water and put the glass on a window-sill where it will be in the sunlight. After a few hours examine the celery.

You will see that the red liquid has traveled up through the pipes and has gone into the leaf. If you break the stalk of celery, you can easily find the pipes, because they will be colored red by the water. It will be very easy for you to take out one of these tubes, or pipes, and examine it. You can see that the water has traveled up these tubes to the leaves. Tree trunks and branches have water-carrying tubes and so do the stems and branches of shrubs.

Before you can understand how a plant makes food, you will need to know some things about the leaf of a plant. People never really understood the structure of a leaf until they began to use microscopes. Then they could see how leaves are made. They found tiny openings in the leaves, and they discovered that plants get air through these breathing pores.

These breathing pores are really little doorways to let air come into the leaf. No one ever knew just how air got into a plant until these openings were discovered with a microscope.



If you look closely at a leaf, you can see the veins.

Now examine the leaves of the celery stalk that you put in the colored water. Has any of the red water traveled into the leaves? In what part of the leaves do you find it? These colored places are the veins of the leaf. You may wish to color different kinds of stems and leaves and examine them. A microscope will help you see the structure.

The water from the ground travels through the veins of the leaf. On this page is a picture of a leaf that shows the veins. Do you see that they are in all parts of the leaf?

If you looked at a leaf under a microscope, you would see hundreds of tiny green dots that are scattered through the leaf. They make the leaf green. You cannot see these little dots of green material except through a microscope. They are very small, but they are very important. Without this green material the plant cannot make food for itself.

You have now found out four important things that will help you to understand how green plants make food.

1. The materials that plants need to make food are water, minerals, and air.

2. Minerals dissolved in water enter the plant through the root-hairs.

3. The water and minerals go to each leaf through tubes in the roots and stems. They go to all parts of the leaf through veins.

4. Air gets into the leaf through tiny openings in the leaf.

* * *

1. Explain how water gets from the soil to the leaf.
2. Why was not all the celery stem colored by the red liquid?
3. What is one important use of a plant stem?
4. On St. Patrick's Day florists often sell green carnations. How do you suppose they make the flowers green?

How does a leaf make food?

NOW SUPPOSE that you can look inside a green leaf and see what happens there as food is made. First, you would probably like to know just what kind of food green leaves can make. They can make sugar, and from the sugar they make other kinds of food. It may seem strange to you that the sugar

Sugar-cane does not look like a factory, but it makes all our cane sugar!

that is in your sugar bowl at home was once inside a leaf. But it was. When it was in the leaf, it looked quite different from the sugar that you eat.

You have eaten sugar made from a plant called sugar-cane. Probably you have also eaten sugar from sugar-beets. Perhaps you have eaten sugar from maple trees. You know, of course, that there is no sugar in the soil. And there is no sugar in the air. The green leaf has made the sugar out of elements from the soil and the air. In the experiment on page 207 you heated sugar to separate the elements that sugar is made of. You found that sugar is a compound. Plants can put these elements together to make sugar and other kinds of foods.

Where are the materials that the leaf will use to make food? You know that the leaf needs two things—air, and water with dissolved minerals in it. Here comes the water up from the roots, through the stems, and into the veins of the leaf. Air is coming in through the tiny openings in the leaf. One more thing is needed before the leaf can begin its work of food-making. Can you tell what it is? Try this experiment and see if you can find out.

Select two plants that are very nearly the same size. Place one on a window-sill where the sun can shine on it. Place the other one in a dark closet or a dark drawer. Water both plants every day, and be sure that the one in the dark place has plenty of air, just as the one on the window-sill has. Why do you think that this is important?

After a week has passed, put the two plants together again. Do they still look alike? Are the leaves green on one plant but yellow on the other? Why does the plant that has been on the window-sill look better than the other one? Is it because it had more water and air? If you did the experiment carefully, you proved that sunlight is necessary for growing plants.

But you have not yet found out what happens to the water and the air in the leaf. Let us see what happens. You know that air is a mixture of gases. One of these gases is carbon dioxide. The green leaf takes carbon dioxide from the air, puts it together with water, and makes sugar. This is a chemical change. If you mixed water and carbon dioxide together, you would get soda-water. But the green leaf makes a chemical change. It puts water and carbon dioxide together and makes a new material, sugar. The sugar has different characteristics from either water or carbon dioxide.

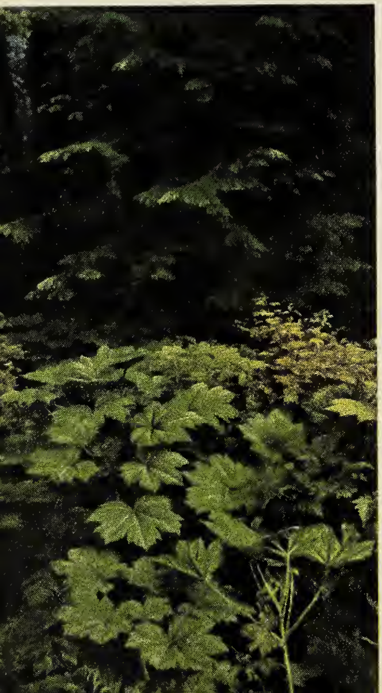
Do you see now where the black carbon came from when you heated sugar? It was part of the carbon dioxide that the plant took from the air. A chemical change took place, and something new was made inside the leaf.

This chemical change cannot happen without sunlight. Plants cannot make food at night, and they cannot make it in dark caves in the earth. Deep down in lakes, oceans, and rivers there are no green plants, because sunlight cannot go far down into the water. This chemical change cannot happen without the green-colored material, either. Plants like toadstools and puffballs cannot make food. They cannot put water and carbon dioxide together to make sugar because they do not have any of this green material in them.

Scientists have studied the plant factory for many, many years, but they still do not know just how the green plant makes food. They know that a plant needs air, water, minerals, green material, and sunshine. But scientists do not know exactly how the food is made. They know that sugar is made by the plant because they can prove that leaves and other parts of plants have sugar in them.

But sugar-making is not the whole story of the green food-factory. Just as soon as the sugar is made, the plant goes to work changing the sugar into something else. First it changes the sugar into starch. You have probably seen the cornstarch in your mother's cupboard. It was made in the corn plant.

Study the way in which the leaves of these plants are arranged. Does this help them make food? Why do you think so?



Scientists have made experiments and have discovered a simple way to tell whether a material has any starch in it. You can easily test some parts of plants the way scientists do and find out whether the plants have starch in them.

Get some iodine—the kind you sometimes put on cuts. First put a drop or two of iodine in a little

Which of these foods have starch in them? How would you find out?

clear water. Does any change take place? Now put a little starch in some water and add a few drops of iodine. What happens? Scientists have found that iodine will always make starch turn to a bluish-purple color.

Now suppose you test a potato and see if there is any starch in it. Scrape a peeled potato with a knife and put the scrapings into a little water. Add a few drops of iodine. What happens? Is there starch in the potato? Is there starch in corn?

The plant factory is not through with its work when it makes starch and sugar. It can make other food from the sugar. One of the foods that some of the plant factories make is called *fat*, or oil. Crush some peanuts and let them stand on a piece of paper. Is there an oily spot on the paper? This oil was made in the plant and stored in the peanut. Olive-oil and cotton-seed oil come from plants.

Other kinds of food are also made by plants. These foods contain the same elements as starch, and, in addition, some of the minerals from the soil. You will learn about these foods later on in your science study.

* * *

1. Tell what is happening in the leaf factories near your house or school.
2. How would you find out whether there is any starch in bread?
3. Of what use is each of the following in manufacturing food in a leaf? Water, sunlight, veins, tubes in the stem, openings in the leaf, air.
4. How is a green plant's way of getting food different from an animal's way?
5. How do you know that the manufacture of sugar by the green plant is a chemical change?
6. Why does the grass under a board get yellow?
7. In Unit One find a picture of a plant that cannot make its food. Why can it not make food?

What becomes of the food made by the leaf?

THE FOOD made in the leaf is used by the plant in much the same way that food is used in your body. The food in your body is carried to every part of your body by the blood. You know that tubes carry water and minerals up to the leaf. Other tubes carry food through the plant. This food is carried in the *sap*. Sap goes to every part of the plant—to the branches, roots, buds, seeds, and flowers. Some of the food is used to make the plant grow. The stems and roots get longer and thicker. The buds get larger and make new leaves and flowers. Every part of the plant must have food, or it cannot grow.

Not all of the food that the plant makes is used as the plant grows. Much of the food is stored in the plant. The tubes carry food to the roots, and some of it is stored there. If much food is stored in the roots, they become very large. Carrots, beets, radishes, sweet potatoes, and parsnips have big roots that are full of stored food. Some of the food is stored in stems of plants. We eat the stems of celery and asparagus. The seeds get some of the stored food, too. The food in the bean and corn seeds was made in the leaves of the plant and was carried to the seeds. So was the food in wheat and other grains. All seeds have stored food in them.

When we eat plants, we eat this stored food. Peas, corn, beans, and nuts are seeds full of stored food. Carrots, turnips, beets, and radishes are roots full of stored food. We also use food stored in the stems of celery and asparagus, and in the leaves of lettuce and cabbage. Our cows, pigs, and chickens eat the stored food in plants, too.

But the plants also use this stored food for themselves. Many kinds of trees drop their leaves in the fall, but the trees are not dead. In their roots, trunk, and branches is stored food. The stems and leaves of many plants die during the winter. But their roots are in the earth and do not freeze. In spring the stored food in the roots is used, and new stems and leaves begin to grow. Many green plants store food in *bulbs* and use it in the spring to grow. Lilies, daffodils, hyacinths, and tulips have bulbs.

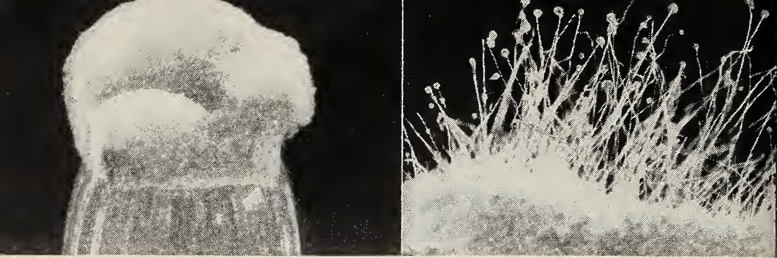
Food stored in the seeds of plants is used by the seeds when they begin to grow. A seed is just a tiny plant surrounded by food. When you sprouted the lima beans to show the root-hairs, you probably noticed that as each little plant grew larger, the halves of the bean became smaller. They became smaller because the food inside them was being used up by the young growing plant.

* * *

1. A lion does not eat plants. It eats other animals. Does the lion depend upon green plants for its food?
2. Why is it necessary for plants to store food in seeds or roots?
3. In what parts of the plant is food stored?
4. What parts of a plant have you eaten this week that had stored food in them?
5. How does food get from the leaf factory to the stems, roots, and seeds?
6. How does our supply of milk, meat, leather, and wood come from the food that was once in a plant?
7. What are two uses of the stored food in seeds?

How do plants that are not green get food?

ON PAGE 241 you read that green plants cannot use other plants for food. But that is not true of all plants. Plants that are not green use other plants for food. Such plants even use animals for food! Of course they do not eat plants and animals



in the same way that people and animals eat them. These plants that are not green cannot change water and carbon dioxide into sugar and starch because they do not have the green material that makes the chemical change take place. So they have to use food that green plants make.

You read about these fungus plants in Unit I. Bread mold is one of them. It has no green material. Suppose you start some bread mold growing. Moisten a piece of bread, lay it in a dish, and leave it exposed to the air for a few hours. Then cover the bread with another dish and leave it in a warm place for a few days. What do you see?

Study the mold carefully. If you could see it under a microscope, it would look like the picture on this page. The bread mold sends little threads down into the bread. These threads soak up the food in the bread. The mold is using the food made by green wheat plants that grew in the soil, the air, and the sunshine. Molds will also grow on damp leather, on meat, on jelly, and on almost any kind of food. Molds will even grow on live plants and soak in food that the plant is making.

You have seen puffballs and toadstools or mushrooms growing in the ground. They are other kinds of plants that are not green. They may seem to grow in the ground, but they are not taking minerals from the soil and carbon dioxide from the air. They are just soaking in food from the decayed bodies of plants and animals that have died and fallen to the ground. These decayed bodies have become mixed with the soil.

You never see toadstools and puffballs growing on sandy beaches. They grow in fields and forests where there are plenty of plants and animals to die and become mixed with the soil. Did you ever see a white or brown fungus plant growing from the side of a tree? There is a picture of one on page 35. These fungus plants are using the decayed parts of the tree for food.

* * *

1. Make a list of things on which you have seen molds growing.
2. When molds grow on foods, the foods decay. Is decaying a chemical change? How can you tell?
3. Make a collection of plants that are not green.
4. Bring samples of different materials on which mold is growing. Examine the mold with a magnifying-glass.

Why can man raise these living things for food?

How do we get food?

You can surely tell many, many things about how we get our food. But suppose someone said to you, "How does your structure help you to get food?" What would you say?

First of all, you would think of arms, hands, fingers, and teeth. These all help us to get food. We can pick fruit from trees and bushes with our arms, hands, and fingers. We can plant and dig vegetables with our arms and hands. And there are some kinds of animals that we can catch and kill with our hands, arms, and legs. Thousands of years ago that is the way men got their food. All they had to eat was what they could catch, kill, and gather with their own strength.

But man is different from all other animals in two ways. There are two things about his structure that are different. First, he has fingers with which he can hold on to things better than almost any other animal can. With these fingers he can make things that no other animal could make.

You are probably thinking that monkeys and gorillas have fingers, too. But here is something you probably do not know. Most of these animals cannot touch the ends of their fingers to the end of their thumb. Try it to see just that that means. Then try picking up things without using your thumb to touch your fingers. Do you see that the structure of your hand is much better than the structure of a monkey's paw?

Second, man has a better brain than any other animal. He can think and plan and remember better than other animals. He can tell others what he has discovered. In this way knowledge about the world grows. Man can do many things that other animals cannot do, because he has a better brain.

Now do you see how man's structure helps him to get food? He uses his brain to think out ways of making machines to help plant and harvest crops. With his hands and fingers he makes the machines. He finds out what kinds of plants are best to eat, and he learns how to make them grow bigger and better. He learns how to take care of the animals he needs for food and work. If he needs water, he digs wells or irrigation ditches to bring water for his plants and animals. He builds big factories with machines in them to grind wheat into flour and to put food in cans. In many other ways he uses his brain and his hands to help him get food. Do you see how the structure of man is useful in getting his food?

* * * *

1. In what ways is the structure of man different from the structure of all other animals?
2. Name some tools that man uses to get food.
3. Why do we get food today in ways that are different from the ways men used thousands of years ago?
4. Make a list of all the different kinds of food you have eaten today. Which of these came from plants, and which came from animals?

Questions to Answer

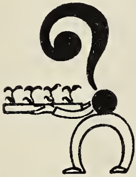
1. If you sprinkled water on the leaf of a plant, would the plant be able to use the water in manufacturing food? Why?
2. When plants are moved from one place to another, why should you be very careful not to damage the roots?
3. Can you explain this sentence? Almost all of the food that we eat was once inside leaves.

4. Write two reasons why you believe that plant leaves are the most important factories in the world.

5. Explain why we would have no food if there were no sunlight.

6. Try to explain fully how a plant manufactures food.

Things to Find Out



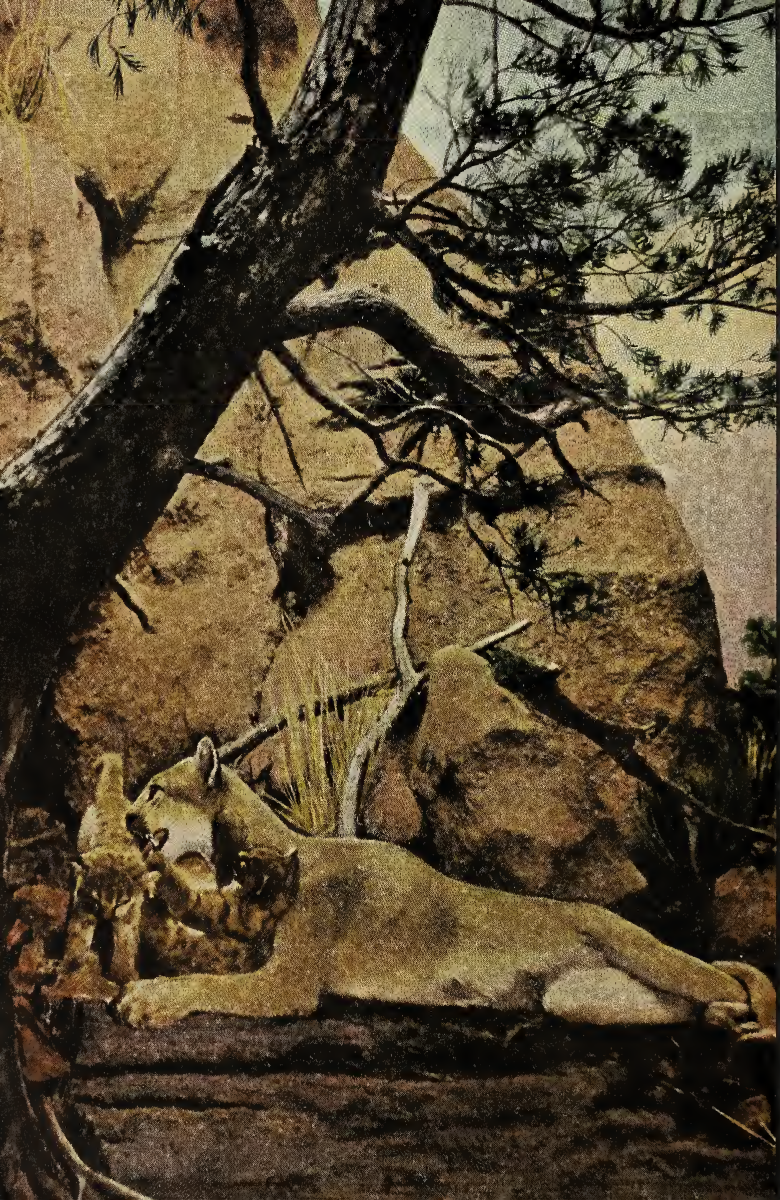
1. Sprout some different kinds of seeds on moist blotting-paper and look for the root-hairs.

2. Place the stems of different kinds of white flowers in colored water and watch the flowers change color. Find the tubes and veins in the stems, leaves, and flowers.

3. Look at the branches of shrubs, trees, and house plants to see how the leaves are placed so that each leaf will get plenty of sun. Draw a picture to show how the leaves grow.

4. Test different kinds of food to see if they have starch in them.

5. Make a drawing of the bills of a humming-bird, a sparrow, an eagle, and a robin. Then explain how the bills of these birds help them to get food.

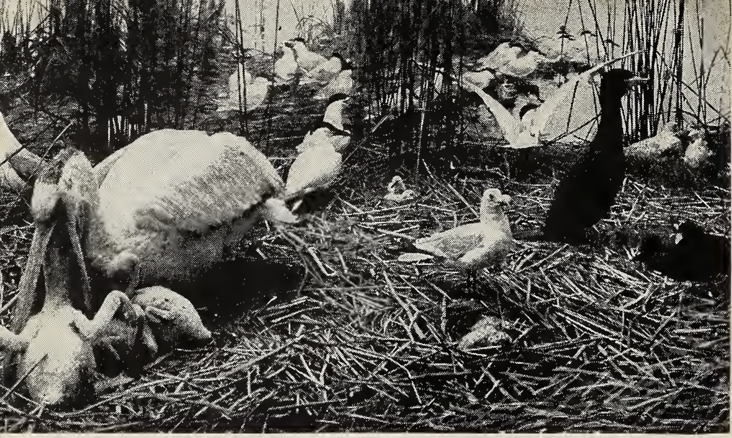


UNIT EIGHT

HOW DO PLANTS AND ANIMALS MAKE OTHERS LIKE THEMSELVES?

A long time ago people had strange ideas about how plants and animals were made. You will laugh at some of their queer ideas. For example, they thought that frogs and toads were made from mud at the bottom of creeks and ponds! Many people believed that insects came from the dew on leaves! Some people thought that mice were made from piles of old rags and that fish were made from water. They even wrote such things in books!

Why do you suppose people had these strange ideas? They believed such things because they did not know much about the world. Even the wisest of men in early times did not know as much as you will know when you have finished your school science study. These people of a few hundred years ago had no microscopes or telescopes. So they never saw some of the things that everyone can see today. People of those times did not know how to experiment, either. They just guessed at things and never really tried to find out whether their guesses were true.



Do the young birds in this picture grow from grass or sticks or mud? Where do they come from?

When scientists began to study the living things in the world, they found out how foolish some of the old ideas were. They studied the structure of plants and animals to see if they could learn how new plants and animals are made. They did experiments with these living things, too. This is the important fact that they discovered: Every living thing comes from some other living thing.

Living things cannot come from non-living things. Frogs cannot grow from mud, and mice cannot grow from rags and paper. Whenever a new plant or animal is made, part of a living plant or animal has been used to start it growing.

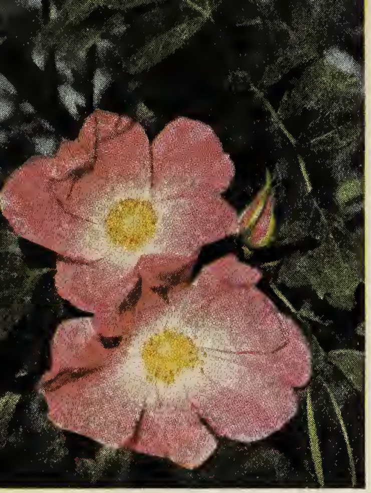
In this unit you will learn how living things make other living things like themselves. First let us see how plants make new plants.

Do you know what part of the plant these big pumpkins grew from? What are growing inside the pumpkins that are very important to pumpkin plants?

Why are flowers important?

WHAT DO you think flowers are for? If you think that blossoms are important just because they help make the world beautiful, then you are quite mistaken. Of course, we all enjoy looking at flowers. Many of us grow them in our gardens just because they are beautiful. But the real importance of flowers to a plant is that they make seeds from which more plants will grow. So each year we have new plants.

Before you can understand how a flower makes seeds, you need to know what its parts are and how they work. Every part of the flower's structure seems to be a special tool to help the flower make seeds.



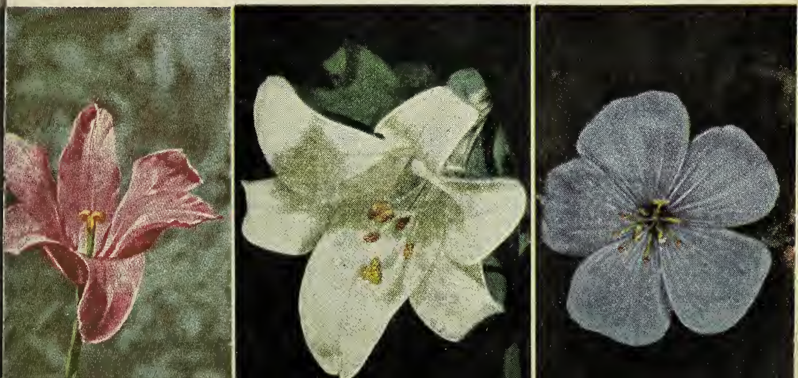
Look at the picture of wild roses on this page. Study one of the flowers to find the different parts of its structure. The pink portion is divided into several parts. Each of these parts is called a *petal*. The petals of flowers are usually brightly colored. How many petals do you find on a wild rose? Examine the petals in several other flowers. Can you find flowers with red or yellow petals?

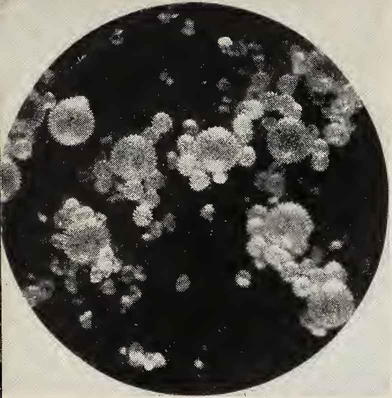
Notice the thin, green parts on the outside of the bud in the picture. Each of these leaf-like parts is called a *sepal*. When a flower is still a tight bud, the sepals cover the petals snugly. As the bud swells, the sepals separate and finally fold back. They have protected the bright-colored petals and the other parts of the flower until the flower opened. Usually sepals are green; but sometimes they are other colors, as in tulips.

The petals and sepals seem important to us because they make the flower beautiful. But the small parts inside the petals are more important to the flower. In the center of the flower is a little stalk called the *pistil*. Around this pistil is a circle of little slender parts. They are called *stamens*. Can you see stamens in the picture on page 268?

Some kinds of flowers have only one pistil; others have more than one. In some flowers the stamens are longer than the pistil; in other flowers they are shorter. Look for stamens and pistils in the flowers below. Many of our flowers have all four of these tools—sepals, petals, stamens, and pistils. But some flowers have only pistils and no stamens. Other flowers have stamens but no pistils. Look at many spring flowers, such as daffodils, lilies, tulips, and blossoms on pear, cherry, or peach trees to see if they have sepals, petals, stamens, and pistils.

Now examine the pistil and the stamens more carefully. What are the ends of the stamens covered with? If you rub your fingers over the stamens, you will see on your fingers something that looks like yellow dust. You know that this is pollen. If you look at pollen under a microscope, you will find that it is made of tiny grains and you will see



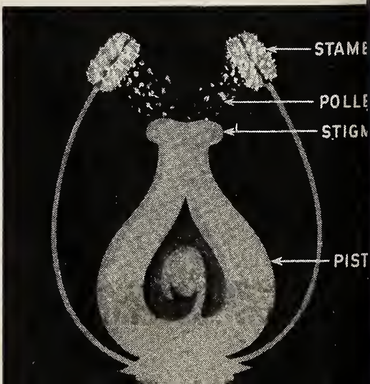


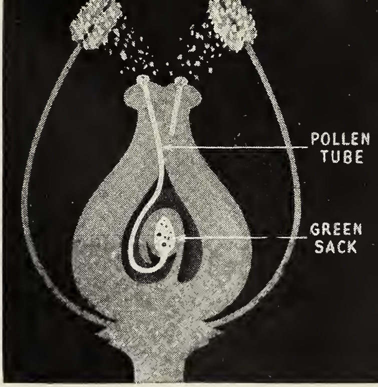
that these grains have many interesting shapes. The picture at the left shows how marsh mallow and dahlia pollen grains look under a microscope. The smaller grains are dahlia pollen.

Study the flower parts in the picture below. The top of the pistil is called the *stigma*. If you touch the stigma, you may find that it is covered with a sticky substance.

How do you suppose that all these parts of a flower can make a seed? First of all, flowers cannot make seeds without pollen grains. These pollen grains must land on the sticky stigma. The pollen must travel from the top of the stamen to the stigma. In some flowers the stamens bend over and carry the pollen to the stigma. In some flowers the stamens are taller than the pistil, and the pollen falls on the stigma. Look on page 30 and find another way in which pollen gets to the stigma.

Thousands of pollen grains are blown about by the wind. Many of these fall to the ground, but





some of them are blown against the sticky stigma of the pistil of another flower. And when bees and other insects fly from flower to flower, some of the pollen grains that they get in one flower brush off on the stigma of another flower. In these ways pollen grains are carried from one flower to another. Many flowers will produce better seeds if the pollen comes from a different flower. Of course the plants must be the same kind. Pollen from a rose will not produce seed if it is carried to the stigma of a geranium. When the pollen reaches the stigma, it has reached the end of its travels. It can go ahead to help make a seed.

Soon after the pollen grain lands on the sticky stigma, it starts to do something interesting. It grows and makes a tiny tube that pushes its way down the neck of the pistil to the green sack at the bottom of the pistil.

* * *

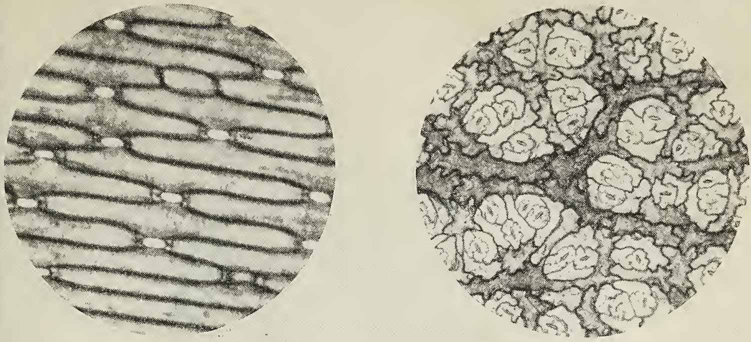
1. How does the pollen get from the stamen to the pistil of the same flower?
2. How does pollen get from one flower to another?
3. Explain what the picture on this page shows.

How does a pollen grain help make a seed?

LOOK AGAIN at the picture on page 271. You see that the pollen tube has grown down into the bottom of the pistil. In the bottom of the pistil there is a tiny egg. Probably you have never supposed that flowers have eggs, but they do. The egg of a flower grows into a new plant, just as a chicken's egg grows into a chicken. Some of the material in the pollen grain joins the egg. The plant egg cannot grow into a seed without the help of the pollen grain. But when some of the pollen grain has joined the egg, the egg begins to grow into a seed. Now let us see how the egg grows into a seed.

Before you can understand what happens, you need to know an important fact about all living things. Did you ever examine a living thing closely to see its structure? You will need a microscope to show you an important fact about the structure of living things. Get a piece of thin skin from the outside of an onion and look at it under a microscope. What do you see? Try to find some of those thread-like water plants that float in the water and look at them under the microscope, too.

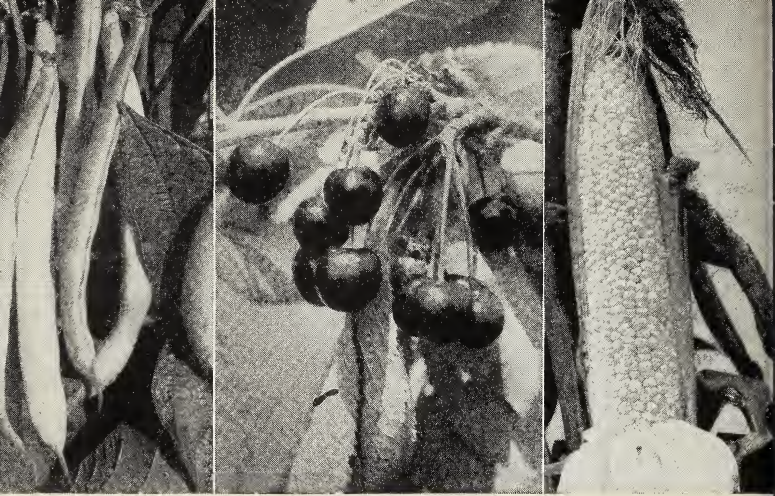
Did the things that you saw under the microscope look like the pictures on the next page? Read carefully what is said in the lines beneath the picture.



Here are some plant cells as they look under the microscope. Some cells are round; some are square; others are oval. Some have many sides. Of course they all look flat under the microscope. But they are often as thick as they are wide.

Could you see the tiny blocks that make up the living things you looked at? These little blocks are called *cells*. Every living thing in the world is made of cells. Your body is made of billions of cells. They are like tiny building-blocks all put together to make your body.

Let us see how our knowledge of cells helps us understand how the egg grows into a seed. A seed is made of three parts. One part is the hard covering called the *seed coat.* The other two parts are inside the coat. One is a tiny plant, all ready to grow. The other is some food for the little plant to use when it begins to grow. Each part of the seed is made of cells. Now let us see how cells grow to make the seed.



Inside the bean pods are seeds for new bean plants. The cherry pits are seeds, and each kernel of corn is a seed.

Inside the pollen grain is a tiny cell. This little cell unites with the egg, which is also a cell. When these two cells unite, seed-making begins. A new cell is made from the egg cell and the pollen cell. This new cell then begins to grow. It gets larger and then divides and makes two cells. These two cells divide and make four. The cells keep on dividing and making new cells. Some of these cells make the tiny plant that is in the seed. Some of them make the food that is stored around the tiny plant, and others make the tough covering, called the seed coat, that protects the seed.

When the seed is planted in the ground, moistened by the rain, and warmed by the sun, the little plant in it begins to grow. It grows by making millions of new cells until it is a big plant like the one that it came from. At first it uses the food that is stored in the seed. Then, when the young plant gets above ground, its green leaves begin to make the food that the plant needs.

* * *

1. Here are some of the things that happen when a seed is made. They are not in the right order. See if you can put them in the order in which they happen.

a) A pollen grain lands on the stigma. 2
b) The flowers grow pollen. 1
c) The pollen grain begins to grow a tiny tube. 3
d) The seed is full grown. 8
e) The pollen tube reaches the egg cell. 4
f) A cell in the pollen unites with the egg cell. 5
g) This new cell divides and makes more cells. 6
h) A hard covering forms around the little plant and its food. 7

2. What are the three parts to every seed?

3. What must happen before the egg in the flower can become a seed?

4. How does each of the following help a flower? Pistil, wind, pollen, sepal, bee, stamen, stigma.

5. Which of these flower parts do you think is most important? Petal, sepal, pistil. Give a reason for your answer.

How do plants without flowers grow new plants?

You already know that many kinds of plants do not have flowers and seeds. Ferns, molds, puffballs, and toadstools or mushrooms do not have flowers and seeds. Where do their new plants come from? Let us see.

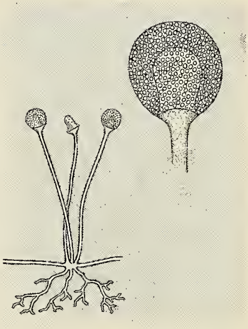
In Unit One you learned that bread mold is a plant, even though it is not green like the plants that have seeds, and it does not have leaves, stems, and flowers. But it is a plant, and it must have some way to make new plants like itself. Instead of growing seeds, bread mold grows *spores*.

Spores are quite different from seeds. Spores and seeds are not at all alike inside. But spores act like seeds, for they grow into new plants. Probably there are many spores in the room where you are reading this book. Would you like to catch some of them and make them grow? You will never know when you do catch them. They are so small that you cannot see them.

Here is an easy way to catch some spores of mold and make them grow. Moisten a piece of bread and leave it in the air of your room for half an hour. Shaking a dusty cloth over the bread may help you catch some spores, for they often collect in dusty places. Now put the bread in a fruit jar and cover it so that the bread will not dry out.

Spores grow best in a warm, moist place. Watch the bread for a few days. What happens?

The spores of the mold will begin to grow. If you look closely, you will see hundreds of tiny threads that have grown over the bread. You can see these little threads better if you use a magnifying-glass. Do you see tiny black, green, or brown balls on the ends of some of the threads? You must be wondering what these little balls are. You know that they are not flowers. Inside these balls are hundreds of spores. The picture on page 258 shows you the little balls. The drawing on this page will help you see what they are like. They are called *spore cases.*



Touch some of the mold and then look at your finger. The tiny bits that look like dust are great numbers of spores. When you touched the mold, several spore cases burst open and left the spores on your finger. Blow them off. Can you see them in the air? When the spore cases get ripe and break open, the slightest breeze will carry some of the spores away through the air. Although millions of spores go sailing through the air, only a few of them may find good places to grow.

Have you seen hair-cap moss like this? The white parts are not flowers. They are little spore cases. New plants finally grow from the spores that are in the cases.

There are many different kinds of molds. Some kinds grow on fruit, some on vegetables, and others on almost anything that lies in damp places. You will find it interesting to look at some mold plants through a magnifying-glass or a microscope.

Another plant that does not have seeds is the mushroom. It grows from spores, too. Underneath the tops of some mushrooms there are little folds. Spores are made on these folds, and when the spores get ripe, they fall to the ground. Then they can grow into new mushroom plants just as the spores of the mold can grow into new mold plants.

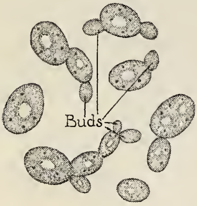
Perhaps you may find mushrooms in the fields or woods. Bring some of these mushrooms to school and carefully lay them on a white sheet of paper. In a few hours you may see that the paper is colored by hundreds of spores that have dropped from the mushrooms.

Did you ever see a fern plant that had rows of brown spots on the underside of each tiny leaflet? Some people think that these are harmful to the plant; so they pick them off! They are really little spore cases. Ferns do not have seeds, even though they are green plants. They have spores, instead, and the spores grow in these tiny brown dots on the fern. When the spores fall to the moist earth under the fern plant, they begin to grow.

You have now learned how some plants use spores and other plants use seeds to make new plants like themselves. Have you ever heard of any other ways to make new plants grow from old ones?

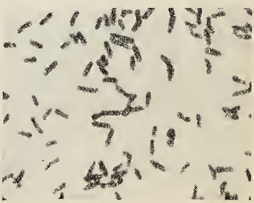
You know that trees, flowers, and vegetables are all plants. You have seen them often, because they grow almost everywhere, and you make use of them every day. However, there are plants so small that we would not know anything about them if it were not for the microscope. The microscope makes them appear much larger than they really are; therefore we can see them and study them. One of these small plants is the yeast plant. If you looked at it through a microscope, you would see that the yeast plant has no leaves, no stem, and no roots. It is made up of just one cell. Of course it has no flowers and no seeds.

How does a yeast plant make another yeast plant? Look at the picture on page 280. Do you see little swellings on some of the one-celled plants? These swellings are called *buds*. These buds grow into new yeast plants.

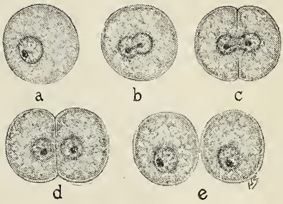


Would you like to get a yeast cake and grow some yeast plants? A yeast cake has thousands of tiny one-celled yeast plants in it. These are mixed with flour. The plants are alive and will start growing if you give them the right kind of food. They must also be moist enough and warm enough.

Fill a test-tube about three-fourths full of warm water. Crumble a piece of yeast cake into the test-tube. Then add a teaspoonful of sugar for food. Put a cork lightly into the test-tube and shake the tube until the yeast and sugar are thoroughly mixed. Then watch to see what happens. Does the cork pop off? Can you see bubbles in the test-tube? These bubbles are carbon-dioxide gas, and they may push the cork up. When yeast grows, it gives off carbon-dioxide gas. If you have a microscope, watch these yeast plants grow.



Now let us see how bacteria grow. They are the smallest of all plants. The picture at the right shows how some bacteria look when the tiny plants are magnified two thousand times. Each plant is just one cell. Yeast, you remember, is a one-celled plant, too. Bacteria are even smaller than yeast plants! How do these very small plants make others like themselves? Each tiny plant divides and makes two plants. Each of these two plants grows larger and then divides. Then there are four plants. In this way these one-celled bacteria make new bacteria.



* * *

1. How is a spore like a seed?
2. How do yeast plants make new plants?
3. What does the picture on this page show?

What other parts of plants will grow into new plants?

SUPPOSE you have a plant in your garden and you want to grow a new plant from it. You do not want to wait for it to blossom and grow seeds. How can you get this new plant? That would depend on what kind of plant it is.

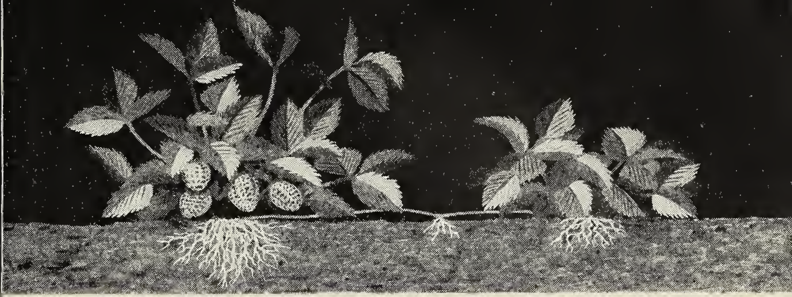
Suppose the plant is a geranium or an ivy. Ivy, geraniums, and many other plants will grow from *cuttings*. A cutting is a piece of a plant that will grow into a new plant.

Follow these directions to make and grow a cutting from an ivy. Take the cutting from the plant with a sharp knife, but be careful not to cut yourself. The cutting should have two joints, one near the top of the stem and the other near the bottom.

Plant the ivy cutting in some sand so that the lower joint is covered. Keep the sand moist and put the cutting in a light place, but not in the sun. It may take several weeks for the roots and new leaves to start growing. If you want to see the roots as they begin to grow, put the cutting in a vase of water instead of in sand.

When the roots and new leaves have begun to grow well, you can plant the cutting in a pot of soil. You will soon have a good-sized ivy plant that started from a piece of the stem of another ivy plant. You might experiment with cuttings from plants such as the geranium, or from grapevines, poplar trees, and willows.

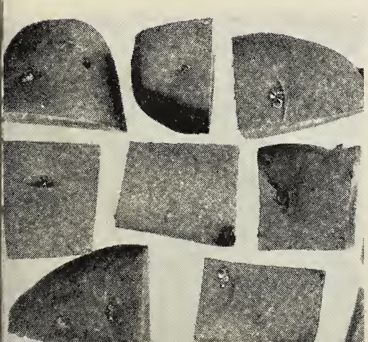
Even the leaves of some plants can grow into new plants. Take a leaf from a begonia plant and lay it on moist sand. Cover the edges of the leaf with



sand, and keep the sand moist. The leaf will soon begin to send tiny roots into the sand. If the leaf is left on the moist sand, tiny shoots will come up from the edges of the leaf. In this way one leaf may make many plants.

Some plants send out stems that grow along the ground. When these stems, or *runners*, touch the moist earth, they may begin to grow roots. The roots reach down into the earth, and then new stems and leaves grow up into the air. Soon a new plant is made. The picture above shows a strawberry plant making new plants in this way.

The vegetable that we call a potato is really a thick stem that grows under the ground. Do you see the "eyes" on the potato in the picture? The eyes are buds on the stem. The inside of the potato has food that the buds will use when they begin to grow.

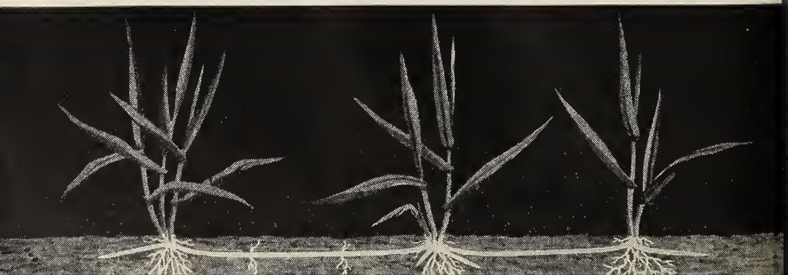


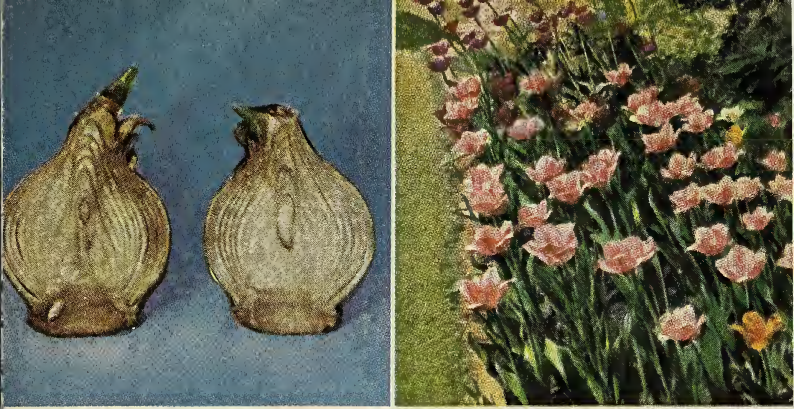
The potato at the left has been cut into pieces.

Each piece has an eye and enough of the food part to make it grow. Try this experiment to find how new potatoes are grown. Put a white potato in a vase, or jar, of water so that only one end of the potato is in the water. As you watch the potato for a few weeks, answer these two questions. What is happening at the eyes of the potato? Why is the potato shriveling and getting smaller?

When the bud, or eye, starts to grow, it begins using the food stored in the potato. When potatoes are cut for planting, why must there be at least one eye in each part planted?

The picture below shows another way that some kinds of plants have of making new ones. This quack grass has sent out many roots. New plants are growing from these roots. Even if some of these roots break off from the plant, they will begin to send up shoots, and new plants will grow. Some of the most troublesome weeds in gardens and fields make new plants in this way. Quack grass is one of these weeds. Unless the roots are pulled out, they will make new plants. Plants that make new ones in this way are hard to get rid of.





At the left is a bulb that has been cut in two. You can see the baby plant and the layers of food around it. Why can tulips like those at the right grow up and bloom quickly from bulbs?

Some plants will grow from bulbs. Suppose you examine a bulb to see why a plant can grow from it. Get an onion bulb and cut it in half. What do you see in the center? This tightly folded little bud that you see in the center of the bulb is a baby plant. Notice the many layers that surround the tiny plant. Peel off several of them. These layers wrapped around the baby plant are stored food which the young plant uses as soon as it begins to grow.

Plant some flower bulbs, such as daffodils, hyacinths, and tulips, and watch how quickly they grow and bloom. Roots grow down into the soil from the bulb, and stems and leaves grow above ground. Soon the plants have flowers on them. Many of our early spring flowers grow from bulbs.

You have seen that almost every part of a plant may make a new plant. The flowers of most plants can make new plants because they can make seeds from which the new plants grow. The roots and stems of some plants can start new plants. Bulbs and potatoes are underground stems full of food to help new plants grow from the buds that are on the stems. Even the leaves of some plants can grow into whole new plants.

* * *

1. How are these plants alike in their way of making new plants like themselves? Mold, mushrooms, ferns.

2. How could you prove by experimenting that these sentences are true?

a) There are mold spores in the air.
b) Mold will not grow in very dry places.
c) Several parts of plants may be used to make new plants.
d) Mold does not come from bread.

3. Name all the parts of a plant from which new plants can grow.

4. Name a plant that grows new plants from:

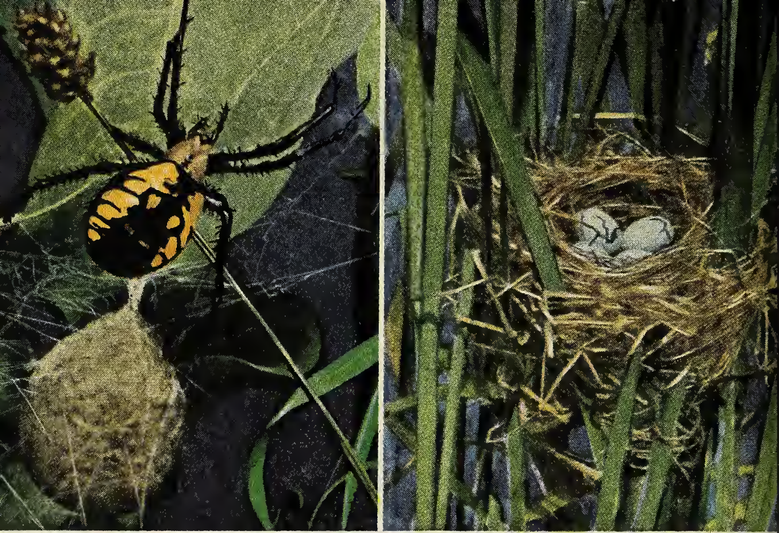
seeds
spores
bulbs
cells dividing
stems
roots
leaves
cells budding

How do animals make more of their own kind?

You have learned how plants make other plants like themselves. All of these ways of making new plants are alike in one way. When stems are used to make new plants, part of the old plant is taken off and planted in the earth. When leaves are used to make new plants, part of the old plant is taken off and used. When roots are used to make new plants, part of the old plant goes to make the new one. When plants are made from seeds, part of one plant (the pollen) adds itself to another part of a plant (the egg), and these two parts make a seed. The seed grows into a new plant. The seed, too, is part of an old plant. Whenever a new plant is made, some of the old plant is used in the making of the new one.

Now let us see how animals make more of their own kind. You know that some animals hatch from eggs, and some are born alive. But they are all like plants in this way: They all come from some other living thing.

Of course you remember the six important groups of animals—mammals, birds, fish, reptiles, insects, and amphibians. Let us find which of these hatch from eggs laid by the mother and which are born alive. You know that birds come from eggs. When the female bird has laid the eggs in her nest, she

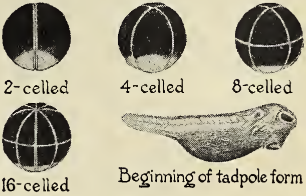


When you have read page 289, tell what will probably happen inside the bird's eggs. The female spider places her eggs in a silken case. Have you ever found a case of eggs like this?

sits on them so that they will be kept warm. Sometimes the male and the female birds take turns sitting on the eggs to keep them warm. Part of each egg begins to grow into a baby bird, just as part of the egg in a seed began to grow into a new plant. The rest of the bird egg is food for the baby bird before it hatches.

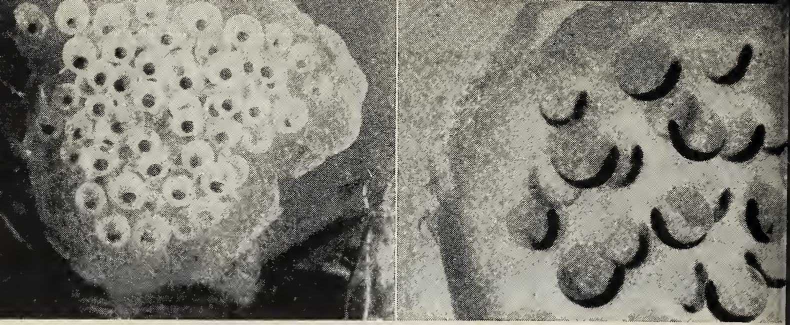
You have seen a broken chicken egg, and you know that it is made of two parts. The yellow part in the center we call the *yolk*. Around the yolk is a white part that we call the *white of egg*. In the yolk of the egg is the tiny cell that will grow into a chicken. This cell is so small that you cannot see it without a microscope.

As the mother bird keeps the eggs warm, the tiny cell in each yolk grows larger and divides into two cells. Soon each of these two cells divides; then there are four cells. The four cells make eight cells, and the eight make sixteen cells. This keeps going on until there are millions of cells, all joined together to make the baby chick that will crack the shell and come out. All the time the cells are dividing, they are using the yolk of the egg for food. The picture above shows you how a frog's egg divides into two cells, then four, then eight, and so on, until a tiny tadpole is formed. The tadpole keeps on growing because the cells it is made of keep on dividing.



Each living thing begins as one little cell and grows by dividing into more and more cells.

Insects are another group of animals that lay eggs. The female of some kinds of insects lays tiny eggs that hatch into little wiggly *larvae.* A *larva* does not look like its parents. After the larva has grown, it changes into a *pupa.* From the pupa comes the full-grown insect. Some insect eggs, though, hatch into little creatures that look much

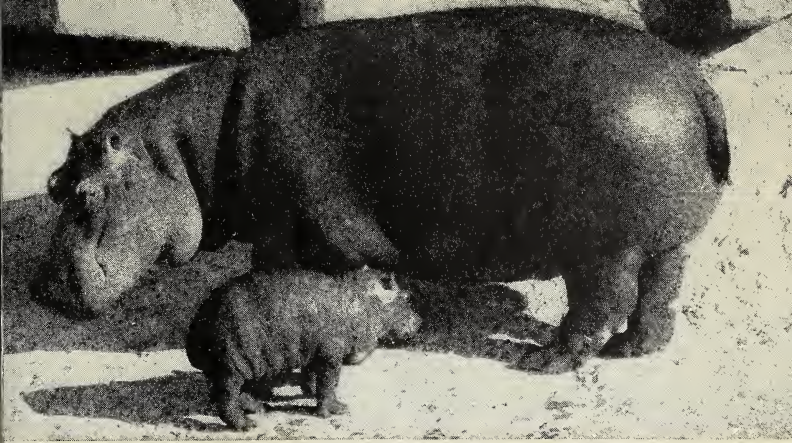


These are salamander eggs. They are laid in the water. The picture at the right shows that the cells have already divided many times. You can see the young salamanders.

like their parents, except that they do not have any wings. A grasshopper egg, you remember, hatches into a little grasshopper without wings. Most female insects lay hundreds of eggs.

You remember that frogs and toads are amphibians. Amphibians also hatch from eggs. The mother frog and the mother toad lay hundreds of eggs in the water. These eggs hatch into little tadpoles that do not look at all like the mother or father. But these tadpoles grow and change, until finally they are little frogs and toads that look just like their parents.

Perhaps you have seen fish eggs in the water. One female fish may lay thousands of eggs. You will generally find fish eggs in some shallow part of a stream, pond, or lake. Every egg is a tiny cell surrounded by food. The eggs hatch into baby fish. But some kinds of fish are born alive. Many kinds



This baby hippopotamus was named Puddles by his keeper at the zoo. Puddles and his mother are mammals. Each came from a single cell. Do you think you can see any hair on the big "hippo"? Look at other pictures of these animals to see if your answer is right.

of sharks and all guppies are born alive. Perhaps you have some guppies in your aquarium.

Nearly all reptiles hatch from eggs. Turtles, alligators, lizards, and crocodiles all hatch from eggs. Did you ever find any turtle eggs in a sand bank along a river? Many snakes lay eggs, but some kinds of snakes are born alive.

Baby mammals are born alive instead of being hatched from eggs laid by the mother. You remember that mammals are animals that have hair or fur on their bodies and breathe with lungs. Cats, squirrels, dogs, rabbits, pigs, horses, and cows are a few of the different kinds of mammals. After the young are born, they get milk from their mother's body.

Perhaps you are wondering whether every mammal begins as a single cell. Yes, it does. Every living thing begins as a cell. Every animal that is born alive begins as one small cell in its mother's body. The cell divides into two cells. The cells keep on making new cells within the mother's body until the baby animal has grown big enough to be born. While it is growing, it gets food from its mother's body.

You have found that new animals and new plants are made in very much the same way. Every plant and every animal starts from a cell that is part of the parent's body.

All living things are made from other living things. If people of long ago had known this, they would never have believed that mice came from piles of old rags, that water could make fish, and that frogs and toads were made from mud.

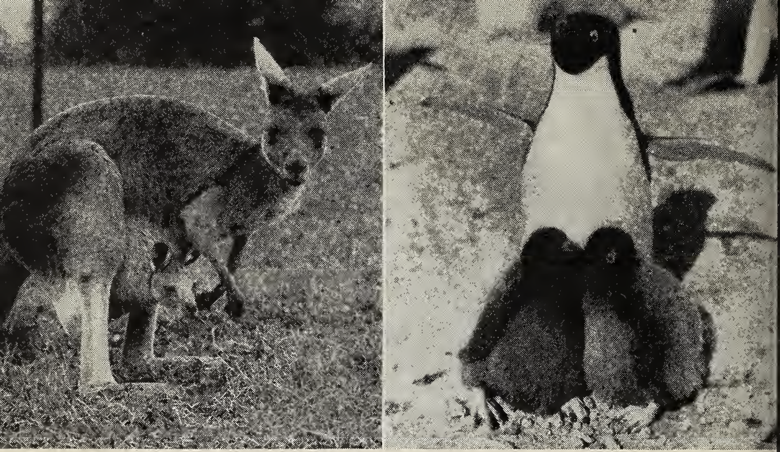
1. How are mammals and birds different in the way their young are produced?
2. How is a bird egg like a plant seed?
3. What is the beginning of every living thing?
4. How do living things grow larger?

Do you know how the mother muskrat and the mother opossum take care of their young? What would probably happen to the young if the mothers were killed? Why?

How do living things take care of their young?

YOU WERE probably about a year old before you could walk. You were three or four years old before you could really talk. Probably even now you would have a very hard time earning enough money to buy all your food and clothes and to pay for a place to live. When you were a baby, you could not have stayed alive without the care that your parents gave you. Even now your parents take care of you.

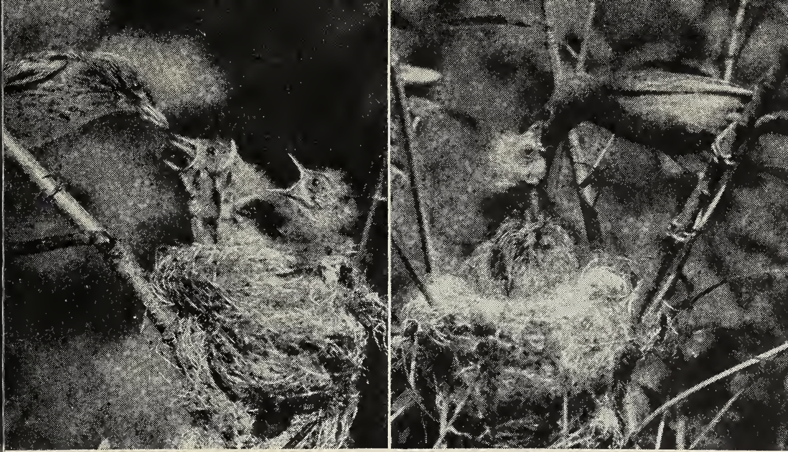
Many kinds of living things would disappear from the earth if they did not have parents that took care



How is the mother kangaroo taking care of her baby? The young opossums on page 293 were cared for in the same way when they were very young. Baby penguins are very helpless and need to be taken care of for a long time.

of them after they were born. You know that little kittens stay with their mothers for several weeks. So do young rabbits, dogs, pigs, cows, and horses. Baby elephants stay with their mothers for two years. They must get food from their mothers because their bodies have not grown enough for them to get their own food. Tiny puppies, kittens, and rabbits are not strong enough to walk far, and their teeth are not big enough for them to chew and bite. Of course they could not protect themselves from other animals that might want to eat them.

Look through this book for as many pictures of baby animals as you can find, and see if you can tell how their parents take care of them.



The full-grown birds in these pictures are yellow warblers. The bird at the right is feeding a baby bird that is not her own. It is a young cow-bird. The mother cow-bird laid an egg in this nest with the warbler's eggs. The eggs all hatched, but the cow-bird has crowded the warblers out of their nest.

Baby birds are usually very helpless for many days after they are hatched. The mother and father birds bring food to them and keep them warm. These young birds are protected by their parents against other animals and against the rain.

If a cat, a hawk, or some other enemy comes near the nest, the mother and father try to drive the enemy away. The parents of the little birds take care of them until they grow big and strong enough to take care of themselves. If the parent birds did not protect them, the young birds would soon die. Then there would be no new bird families to grow up.

Many kinds of living things do not take any care of their young. Most mother insects leave their eggs soon after laying them. When the eggs hatch, the young insects find their own food. Of course, many of the eggs are destroyed before they hatch, and many of the newly hatched insects die before they are grown up. But each mother insect lays hundreds of eggs; so there are always many new insects growing up each year.

There is one thing that many insects do to help their young: They lay the eggs near food for the young. Cabbage butterflies lay their eggs on cabbage plants. Flies lay their eggs on decaying meat or on garbage. Monarch butterflies lay their eggs on milkweed plants. One kind of beetle always lays its eggs near a grasshopper's nest. As soon as the young beetles are hatched, they scamper over and eat the grasshopper eggs. The mud-dauber wasp builds a nest of mud in which to lay her eggs. She puts food in the nest for the young larvae to use when they hatch from the

A butterfly laid her eggs on these leaves, and the caterpillars hatched from them. Why were the leaves a good place for the eggs?

eggs. So they are well fed, even though their mother has gone away and left them.

Most fish, reptiles, and amphibians do not protect their young. Fish, frogs, toads, and salamanders lay so many eggs that there are always young ones growing up, even though thousands of eggs are destroyed and thousands of tadpoles and little fish are eaten by other animals. But there is one kind of fish that protects its young. This fish is called a stickleback. The stickleback builds a nest for its eggs. The father stickleback guards the eggs and fights enemies of the baby fish until they can take care of themselves.

* * *

1. Which animals take most care of their young—animals that have many young or those that have only a few?

2. Did you ever watch a dog or a cat while it seemed to be teaching its young? If you have, tell the class about it.

3. Did you ever see a bird protect its nest against enemies? Tell what the bird did.

Questions to Answer

1. Tell several ways in which animals protect their young.

2. What is a young horse called? A young cow? A young dog? A young cat? A young goose? Look up the names given to the young of some other animals.

3. Some people believe that a horsehair will turn into a snake if it is put into water for three weeks. Do you believe that this is true? How could you prove that your answer is right?

4. Sometimes fruit trees bloom so early in the spring that the blossoms freeze. Does fruit grow on the trees when the blossoms have frozen? Why?

Things to Find Out

1. Examine some of the flowers that grow out-of-doors in summer. Find the parts of the flowers that hold the seeds. Find the parts that make the pollen. Find the pistils.

2. Examine a dead bee under the microscope to see the hairy legs that carry pollen.

3. Try to find out something about Luther Burbank and his work in making new kinds of plants.

4. Sprout some seeds and watch the young plants begin to grow.

5. Visit a greenhouse and ask the florist to show you spores on different kinds of fern plants.

6. Plant some cuttings from geraniums and watch them as they grow.

7. Find some frogs' eggs in a pond. Take them to the school-room and watch for them to hatch. Then keep the young tadpoles in your school aquarium.

8. Visit a greenhouse and find out how different kinds of plants are started.

UNIT NINE

HOW ARE LIVING THINGS FITTED TO LIVE IN DIFFERENT PLACES?

SUPPOSE you wished to find a place on the earth where there were no living things—no plants or animals. Where would you go? Perhaps you might say, "I would go to the North Pole or to the South Pole. At these places the climate is too cold for things to live." But when you read about explorers who have traveled to the poles of the earth, you find that polar bears, seals, penguins, whales, and other animals live in these cold places.

You might say, "I will go into a cave in the earth; probably there are no living things there." But even in cold, dark caves you will find plants and animals. Bats live in caves during the daytime. Of course, green plants that must make their own food could not grow in a dark cave, but mushrooms can grow there. The water in caves often contains fish and other water animals.

Perhaps you would say, "The driest places on the earth surely have no living things. I will go to a hot desert place." On the opposite page is a picture of a desert. Can you see the plants? Small

A marshy pond and a thick forest are very different kinds of places. What kinds of living things do you find in each place?

lizards lie in the shade of these cactus plants. There probably are insects under the rocks, and birds may be flying about.

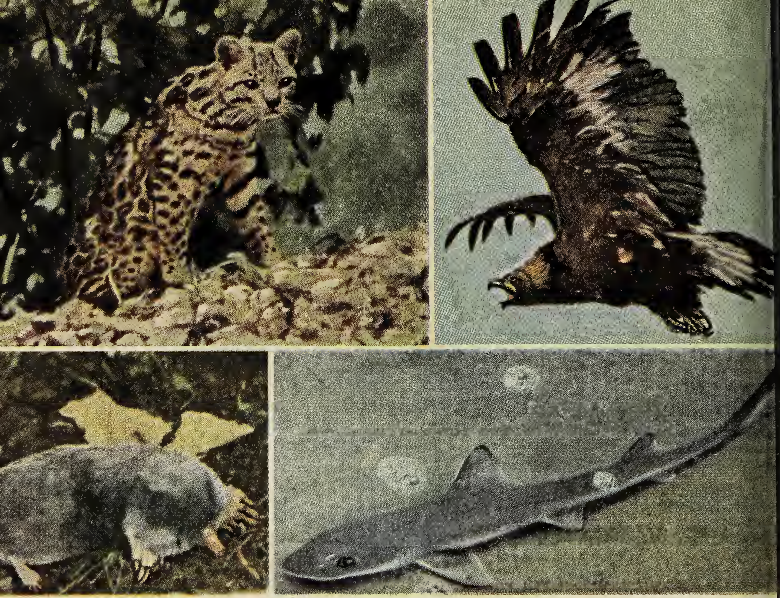
At last you may say, "I'll get into a diving-suit and go down into the salt water of the ocean." But the salt water of the seas and oceans has many plants and animals in it.

It is almost impossible to find any kind of place on the earth where there are no living things. The fresh waters of our lakes and the salt waters of the oceans have many kinds of living plants and animals in them. The fast-moving streams of the mountain canyons make homes for many kinds of insects, fish, and water plants.

Animals and plants live on high mountains. Under the surface of the earth, too, animals are found living in tunnels and burrows. Some of these animals that live under the ground never see the light of day. They find their food and raise their young there in the darkness. Animals live in the hot places on the earth, and they live in the cold places. You can see that living things are found almost everywhere on the earth.

These animals and plants that live in different places on the earth look quite different from each other. Animals and plants of the far north are different in appearance from those that live in the hot jungle. Animals that live in tunnels underground are very different from those that fly in the air. Animals and plants that live in water are very different from those that live on land. Those that live in the desert are very different from the ones that live in damp swamps.

Each of these living things is fitted to live in its special home. The structure of the different kinds of plants and animals makes it possible for them to live where they do. You can often tell by looking at an animal what kind of home it lives in. Look at the pictures on the next page to see if you can tell in what kind of place each animal lives. Of course,



the fish could not live on land and the Mexican leopard would soon die if it were put under water. Birds cannot live under the earth's surface, as ground moles do, and the moles cannot sail through the air.

Plants, too, are fitted to live in certain places. Look at the pictures on the next page, and you will see how true this is. If the cactus were transplanted into the water, it would soon die. If the water-lily plant were taken from the water and planted on land, it, too, would die. The palm tree could not live in water, and it could not live in a very cold place, either.

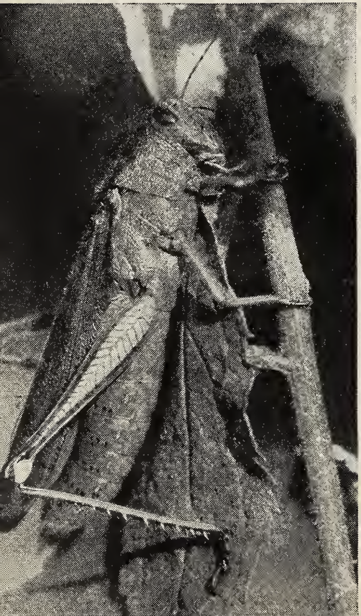
Each of these plants can live where it does because its structure fits it to live there. Let us study some of the plants and animals that live and grow in different places on the earth; then we shall understand how they are fitted to live where they do.

How are living things fitted to live on land?

Pigs, bats, flies, elephants, toads, lizards, birds, and snakes are a few of the earth's land-living animals. They are not very much alike, are they? Even though these animals are very different from each other, they are all alike in one way; that is, they are all able to live on land.

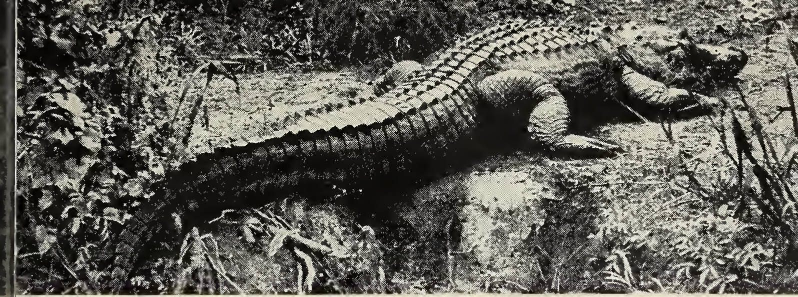
Land animals must have parts that make it possible for them to live where there is air around them and ground under them. These animals have certain parts that make it possible for them to breathe, get food, and move on the land.

All land animals must be able to get oxygen from the air, for they cannot live without it. Do you know what parts of their bodies land animals use for getting oxygen? You have already learned that mammals, birds, and reptiles have lungs. Each of these animals breathes air into its lungs, and then the blood carries the oxygen around through the body, where it can be used by the body.



Some land animals do not have lungs. They get their oxygen through tiny holes in their bodies. Flies and other insects get their air through such holes. In the picture the tiny white spots on the side of the grasshopper show where the air-holes are. The air enters the grasshopper's body through these holes.

The structure of all land animals must help them in another way. It must

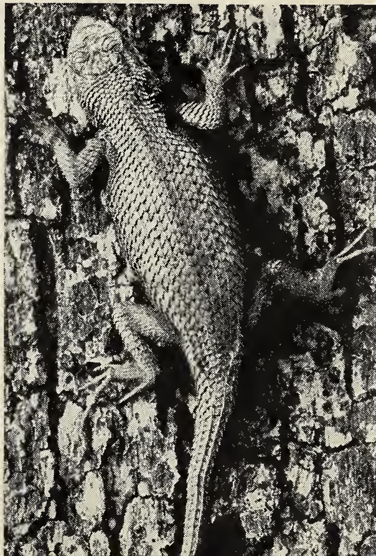


provide them with some kind of covering, or skin, to keep their bodies from drying out. The skin of many land animals is so tough and thick that we can use it to make shoes, pocket-books, and suitcases. Your shoes may be made of horsehide or cowhide. Have you ever seen shoes made partly from the skins of alligators or lizards?

You can see how such a thick covering can keep the body of a land animal from drying out, no matter how long the animal stays out in the hot sun. Lizards have such thick skins that they can live in the hot desert and not dry up.

Some animals, such as frogs and salamanders, have thin skins; so they must live where there is

How is the skin of this lizard different from the skin of the salamander on the next page?



Why could not this salamander live in a dry place?

plenty of moisture, and in the shade where it is cool. If a frog should stay in the hot sun away from water for too long a time, he would dry out and die.

All animals must be fitted to live in the places where they are found. The picture of a ground mole on page 304 shows you an animal that lives in an underground tunnel. Notice how his front feet are made. He uses them to push away the soil. The pointed nose helps him loosen the soil and push it aside.

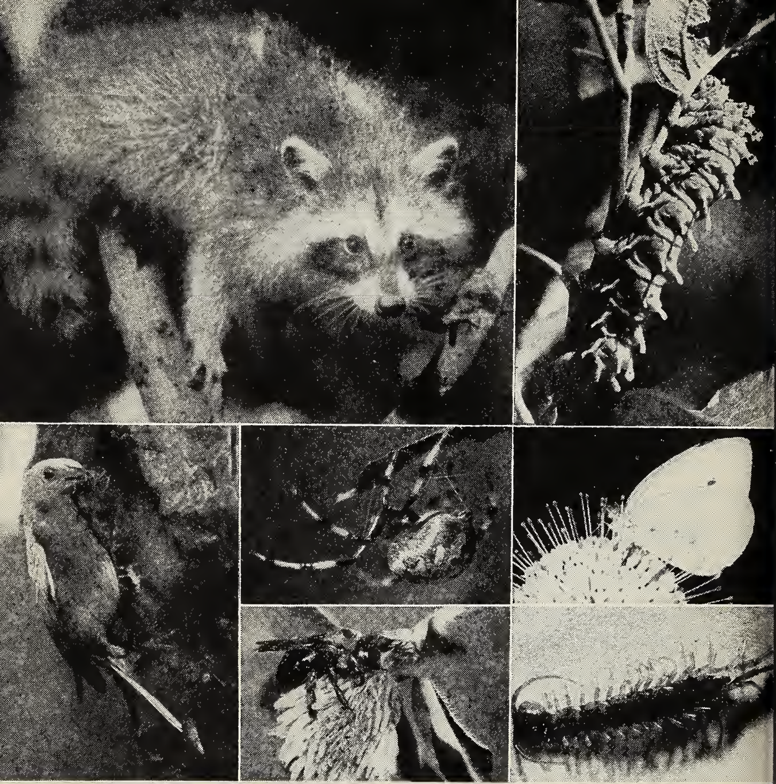
The picture of the hawk on page 304 shows how another kind of animal is fitted to live where it does. Because of its structure, the hawk can fly through the air and catch its food. The hawk could not live and gèt its food without wings. The tail helps to balance and guide the bird while flying. The hawk's "stream-lined" shape helps it to move through the air easily. Many of the bones in the hawk's body are hollow. Can you tell why hollow bones are helpful to the hawk in flying? The claws and the beak are very necessary to the hawk in catching and eating its food.

Some animals are fitted to live in more than one kind of place. The frog can use its long hind legs to jump about on land, or it can use them to swim through the water. The short front legs are used to hold the body up. You have already learned that the frog is an amphibian. When it is young, it lives under water and has gills for breathing and a tail for swimming. But its body slowly changes, until finally the young frog is fitted for both land and water. There are also some insects that live in water when they first hatch and later live on land.

All animals must be able to get food from their surroundings. So they need body parts that will help them move as they hunt for food.

Many land animals have feet that they use when they hop, run, or crawl over the ground. Some have wings and can fly to get their food. The legs, feet, and claws of many animals help them climb

Here are some whirligig beetles, a frog, and some duckweed. Try to find how each is fitted to live in water.

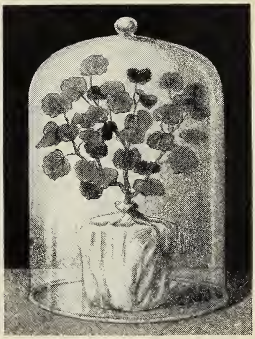


How does each of these animals get from place to place? Notice that the bird, the butterfly, and the bee have two ways of moving.

trees and get food. The opossum, squirrel, raccoon, and monkey, for example, have claws and legs that help them climb about in trees. Look at the pictures of animals in this unit and try to find how the structure of each land animal helps it move about.

Every land plant also has some special parts that make it possible for the plant to live on land. Land plants have a covering that helps them in much the same way that skin helps land animals. This covering keeps the water in the plant from evaporating too rapidly. Some water is always evaporating from the leaves, but if too much water evaporates, the plant will wilt and die.

You can show by experiment that water evaporates from plants. Take a small potted plant. Cover the pot and the soil in which the plant is growing with waxed paper. Then place the plant under a large glass jar. Also place an empty glass jar upside down beside it. Let the jars stand for a day and then look at them. What do you see on the inside of the jar that is over the plant? Where did the water come from that is condensed on the inside of this jar? Why are there no drops on the inside of the empty jar?



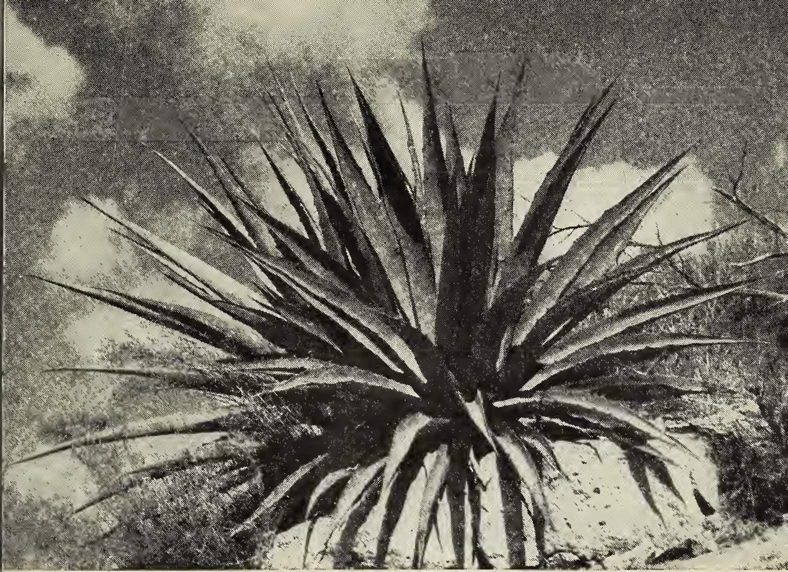
Plants that grow in the desert and in other very dry places have a heavier covering than plants that grow in damper regions. The desert cactus stays alive for a long time with very little water. If you look closely at a cactus plant, you will find that the outside is covered by a thick layer, which is like a tough skin. This thick covering does not allow much water to get out into the air. It saves the water supply that is inside the plant.

Compare the stem of a cactus with the stem or leaf of some small plant that grows near your home. Examine the leaf of a plant from your garden and notice how thin this leaf is, but notice also that it has a skin. Cut open the cactus stem and see how much moisture is stored in it. Examine the skin of the cactus plant. See how thick it is.

The thick leaves and stems of many desert plants store water inside them. Some kinds of cactus plants hold many gallons of water. When there is no rain for a long time, the plant uses this stored water. Sometimes when people have no water in the desert, they crush the pulp inside these cactus plants and drink the juice. Cactus plants even stay alive for a long time after they have been pulled out of the ground, because they use the water that is stored inside them.

A boy once sent a cactus plant to a friend. It was lost in the mail, and nearly a year went by before the box was received and opened. The friend was surprised to find that a fresh sprout nearly an inch long had grown out from the end of the cactus while it was in the box.

Some of the plants that grow in desert regions have



When you have studied this page, tell two ways in which this plant, called the yucca, is fitted for life in the desert.

narrow, thick leaves. Such leaves do not lose as much water in the sun as thin, broad leaves do. They are water-savers, just as the thick stems of desert plants are.

In the desert the only water supply is usually down deep in the earth. Desert plants send out long roots to find this water. Some of these plants send their roots far down into the soil. Others grow roots that spread out for many feet through the soil on all sides of the plant; then, when it rains, these widely spreading roots can take in water from a large amount of soil.

Land plants must be able to get air inside them, too. You know that a plant must have air to help it grow and make food. The structure of leaves fits them for getting air. As you learned on page 246, leaves have many tiny openings in them that take in the air which the plant needs. Land plants could not live without these openings in their leaves.

* * *

1. How does the structure of a land plant fit it to live on land?
2. Why would a maple tree die if you planted it in a desert?
3. Name three ways in which the structure of all land animals helps them keep alive. Give examples of different kinds of land animals and show how each one is helped in these three ways.
4. Compare the structure of a ground mole with the structure of a hawk.
5. Name three ways in which the structure of land animals helps them to get food. Perhaps you can name more.
6. How are desert plants different from plants that live in swamps?
7. Look at the pictures of land animals in Unit One and tell how each animal is fitted to live where it does.

The newts at the upper left are like salamanders. At the right is a big crab. Below him is a starfish, and at the lower left are mussels. Find out how these animals are fitted to live in water.

How are living things fitted to live in the water?

THE ANIMALS and plants in the pictures on this page are fitted to live in the water. Such living things must be able to get their food and oxygen from the water. Let us examine them carefully to see how their structure makes it possible for them to stay alive in water.

Plants that grow in water get their food materials and air through their leaves, roots, and stems, as land plants do. Some of them grow entirely under

water. Others grow so that parts of them float on the surface of the water.

Study the water-lily plants in the picture on page 305. These plants get water through roots that grow in the mud at the bottom of the pond. Their stems grow up through the water, and their leaves float on top. They get air through hundreds of tiny openings that are in the upper surface of the leaves.

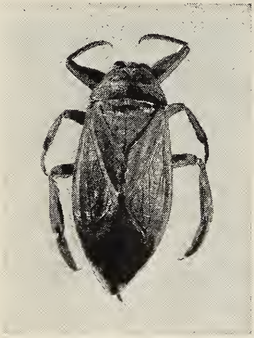
The structure of many water plants helps them to float. The stems and leaves of water-lilies have a great deal of air in them. This air helps them float easily. The leaves of the water-hyacinth, shown in the picture, have very thick parts which contain many spaces filled with air. This air helps to float the plant so that the leaves can get air and sunlight.

Not all water plants are like the water-lily and the hyacinth. Some grow with all their leaves and stems under water. Probably the plants in your aquarium grow in this way. These plants take in water through their stems and leaves as well as through their roots. Oxygen and carbon dioxide that are dissolved in the water go into the plants through the stems and leaves. Plants that take in water through their leaves are not covered with a thick layer, as land plants are. Their leaves have only a thin covering.

The structure of water animals helps them live in water, too. The fish shown on page 304, for example, has fins and a tail that help it glide through the water at great speed in search of food or to escape from enemies. The shape of the fish also helps it live in water. Its body is "stream-lined"; so the fish can move through the water easily and swiftly.

The crayfish has a strong tail, or flipper, that helps the animal move through the water easily. Its legs also help it get from one place to another.

If you have ever tried to catch a crayfish, you know how fast it can move in water.



The giant water-bug uses its six legs to swim through the water in search of food. Do you see in the picture that these legs are flat? Their shape helps the animal push itself swiftly through the water.

The structure of every water animal fits it to live and grow in water. So of course these animals are able to take oxygen from the water. You have probably seen the gills by which fish take in oxygen. The crayfish and many other water animals breathe with gills. Some animals that live in water come to the surface to get air when they need it. Watch the animals in your aquarium and see if you can tell how they breathe.

* * *

1. Give two reasons why the structure of water animals needs to be different from the structure of land animals.

2. Why would a land plant die if it were planted in water?

3. Why cannot a water animal live on land?

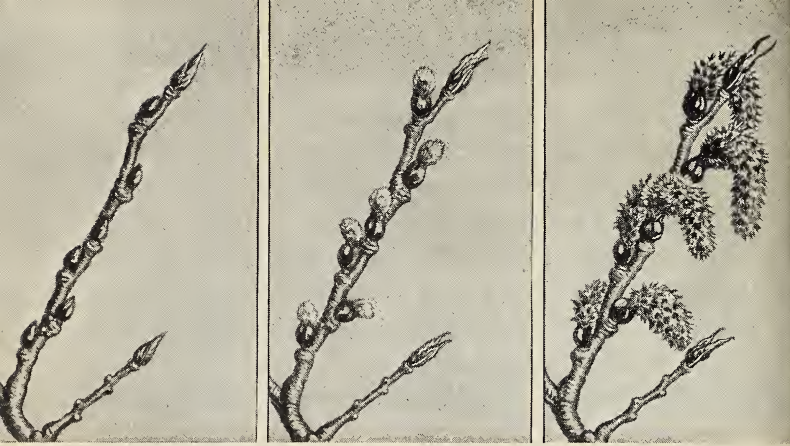
How do living things change as the seasons change?

CONDITIONS in the places where land animals and plants live change from time to time. Sometimes the places are cold; sometimes they are hot. Sometimes there is plenty of water; at other times months pass without any rain. The place where you live is probably cold part of the year and warm at other times. Very likely there is much rain at certain times of the year and little rain at other times. How do you think plants and animals keep alive when these changes in temperature and moisture take place?

The leaves of some kinds of plants roll up when hot, dry weather comes. This keeps the water in the plants from evaporating so fast. You have probably seen corn leaves curled up in summer when the weather was very dry.

When cold weather comes, plants make many changes. A walk through a garden or into a woods will show you some of these changes. A great many plants drop their leaves as the weather grows colder. During the winter the ground is frozen in large parts of our country, and the roots can get no water. Food manufacture stops until the warm spring weather comes again.

If you examine the branches of shrubs and trees in winter, you will find many buds on them. You



The buds on the twig in the first picture grew during the summer and stayed on the twig through the winter. Inside of them are tiny leaves and flowers. These begin to grow when spring comes, as shown in the second and third pictures.

know that these buds were not made in the wintertime. They were made in the past spring and summer when the plants were growing. Some of these buds have the next spring's flowers inside them; others are leaf buds. If you cut these buds open, you will see tiny leaves or flowers inside. If you put the stems of shrubs in water, you may see these buds begin to open. This shows you what will happen to buds on shrubs and trees when spring comes.

Some kinds of plants usually die when cold weather comes. Many of these plants make seeds before they die. The seeds fall to the ground, and there they stay during the cold weather. In spring, when the weather is warmer, some of these seeds sprout and grow into new plants. There are other kinds of plants that keep their roots alive through the winter. The part of the plant that is above the ground freezes and dies. But a new shoot grows up from the roots when the warm spring weather comes.

Animals, too, make many changes as the temperature gets colder. How many of these changes have you ever seen? Some animals grow heavier fur before the cold winter weather comes. Your dog's hair gets heavier in the autumn. Have you ever noticed a squirrel's fur in the fall? It is much heavier. The tail becomes very bushy and helps to keep the animal warm. Muskrats, beavers, raccoons, skunks, and foxes also have heavier fur in winter. This is why animals are often trapped and hunted in cold weather. Their winter fur makes warm coats. In spring much of the fur loosens, and the animals shed part of their heavy coats.

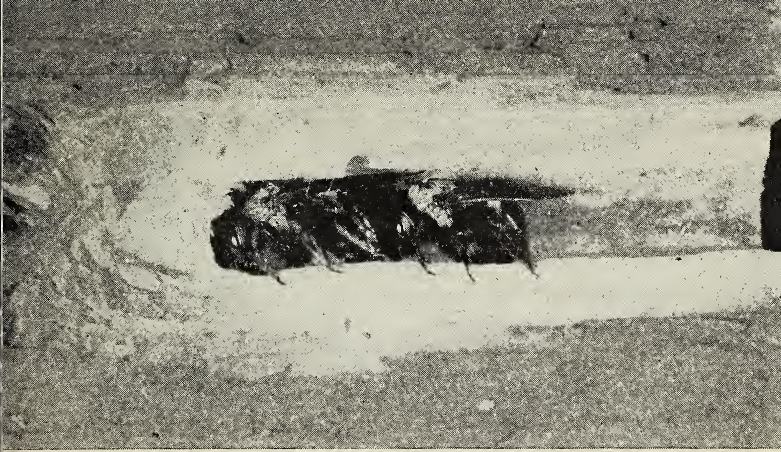
Before cold weather comes, many kinds of birds and some other kinds of animals leave the colder parts of the earth and travel to warmer places. Some birds travel thousands of miles south in the autumn. In the spring they fly back to their northern homes again. When birds and other animals travel like this, we say that they *migrate.*

Have you seen swallows in flocks like this? They are gathering to fly south for the winter.

Scientists do not know exactly why birds migrate, but they do know where many of our common birds spend the winter. They know, for example, that the Baltimore oriole and the ruby-throated humming-bird migrate to Central America. Some birds travel even farther than this. The Arctic tern is the champion traveler. It flies about 11,000 miles to get from its summer home to its winter home.

Some insects migrate, too. The monarch butterfly is one of the insects that migrate. In the fall, when the days become cooler, many of these butterflies may be found clustered together in a tree. They are on their way south to stay until the weather is warm again in the north.

Most insects do not migrate. Some kinds lay eggs in a protected place. After the eggs are laid, the insects die. In the spring the eggs hatch. Other kinds of insects crawl into the ground or creep under the bark of trees or into old logs. Here they lie quietly until the cold winter months



These carpenter bees bore a hole into wood and hibernate through the winter.

have passed. When warm weather comes, they crawl out from their winter homes.

Some animals protect themselves against the cold by digging holes in the ground and staying in them during the coldest weather. Others crawl into rocky caves or into holes in trees, where they stay until warm weather comes again. We say that these animals *hibernate.*

Some kinds of chipmunks dig a long tunnel into the earth. At the end of the tunnel they make one room in which to stay and another room in which to store food. During the autumn days these chipmunks carry nuts and seeds into the storeroom. They use grass to make a nest in the other room. For months during the cold weather the chipmunks are not seen. They are curled up inside their winter homes.

Many other kinds of animals hibernate. Some kinds of bears sleep through the winter in warm, dry dens. They eat a great deal in the fall, and this makes them fat. This fat keeps the bears alive during the cold days.

Groundhogs also store up fat in their bodies in the fall. They stay in burrows all winter. Bats hibernate by hanging upside down in buildings or caves. In cold weather bats do not fly. Frogs and turtles bury themselves in the mud at the bottom of ponds and streams. Snakes crawl down into the ground or bury themselves under old logs in the woods.

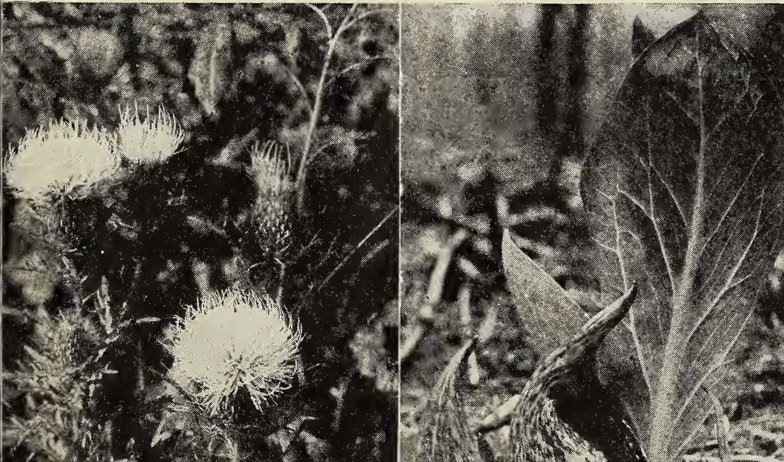
* * *

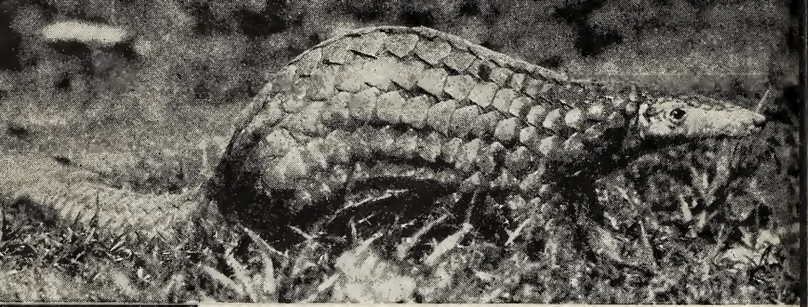
1. How does the region where you live change from season to season?
2. How do the plants in your region change as the seasons change?
3. In what ways do plants live through the winter?
4. How do the animals in your region change as the seasons change?
5. What does *migrate* mean? Name some animals that migrate.
6. Name some animals that hibernate and tell how they spend the winter.

How are living things protected from their enemies?

All living things need food. Animals use other living things for food. They eat each other, and they eat plants. Some kinds of animals, however, are almost never eaten by other animals, and some kinds of plants are seldom eaten by animals. Do you know why this is true?

Here are pictures of plants that are not often eaten by animals. Some plants, like the thistles, have thorns that cover their stems and leaves. The thorns would surely injure any animal that tried to eat these plants. Other plants are not eaten because of the hairs that cover them. Still others have an unpleasant taste or odor and so are left untouched by the animals. The skunk cabbage shown at the right in the picture is one of these. And some plants





This queer-looking animal with thick scales is a pangolin. When frightened, he rolls into a tight ball. At the left are shown a snail, a caterpillar rolled in a ball, a bee, and an ant. How can these animals protect themselves?

are poisonous. Such plants are well protected against animal enemies.

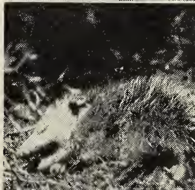
Animals have many ways of protecting themselves against enemies that want to eat them. Do you know of any of these ways? Turtles, snails, and clams have hard coverings protecting their bodies. Porcupines are covered with sharp quills. Many animals have weapons that they use to protect themselves. Bees have stingers, ants have strong jaws, tigers have sharp teeth and claws, and hawks and owls have strong bills and claws. You could make a long list of the kinds of animals that have weapons they use for protection.

Many animals are protected against their enemies by their colors. They look so much like their surroundings that their enemies often look right at them without seeing them. Turtles look like mud; frogs look like grass; and some fish look like the mud or gravel of the creek bottom. Some birds look like the leaves and grass that are around them. Many insects look like the grass or twigs that surround them.

In the pictures at the right notice how much the sandpiper eggs, the toad, the moth, and the owl look like their surroundings. You can easily think of other examples of the way color protects animals.

There are some animals whose color changes when the place where they live changes. For example, in summer the weasel is brown and gray, but when winter comes and snow covers the ground, its fur changes to white. The winter coat of the weasel is called ermine. The goldfinch changes its color as the season changes, too. In summer it is bright yellow. In winter it is gray and brown like the dead grass and leaves.

Some animals, such as the opossum in the picture at the right, have special



habits that help to protect them against their enemies. Some pretend to be dead and in this way escape being captured. Perhaps you have heard of "playing 'possum." The opossum is an animal that pretends it is dead when it fears some enemy. It lies very still and stiff. Then, when its enemy leaves, it "comes to life" and hurries away to safety. Some kinds of snakes and insects have the same habit.

A great many kinds of animals protect themselves by building strong homes that their enemies cannot enter. Beavers and muskrats do this. The beaver house has thick walls of mud and sticks as shown in the picture below, with the doorway under the water. Wolves and coyotes cannot break through these walls, especially when the walls are frozen hard in winter.

The picture at the right, below, shows a caddis worm which lives in the water, in a house that it carries around with it! It builds this house, or case, of sticks and leaves. The case looks so much like the bottom of the stream that enemies of the caddis worm are not likely to see it.

Many animals escape being captured by their enemies by hunting for their food mostly at night,

when their enemies are asleep. Raccoons do this, and so do beavers, deer, rabbits, and muskrats.

1. Name four ways in which different kinds of animals protect themselves against their enemies.

2. How do the following animals protect themselves? frogs, toads, deer, porcupines, opossums, beavers, and hawks. What characteristic of the skunk-cabbage protects it?

How are people able to live in almost every place on the earth?

Of all the living things on the earth, man can do the greatest number of things to protect himself and to make himself comfortable. He knows how to keep warm and how to get food to eat. He can make both animals and machines work for him. He has made many kinds of tools to help him, and he has learned to make and use many kinds of materials.

Man can take trees that grow on the earth and saw them into boards. He can use the iron in the earth to make nails. With the nails he can fasten the boards together and make a house. He can make glass for the windows from sand, and he can make bricks for the chimneys from clay. If he wants to build a large house or factory, he takes iron from

Man can tunnel into the earth for coal. He has tools to dig out the coal, cars in which to load it, motors to move the cars, and steel tracks for the cars to run on.

the earth and makes it into steel. The steel helps to make the building very strong.

When the building is finished, it keeps out the cold wind and the hot sun. Rain and snow cannot get through the roof or the walls. To make the building more comfortable, man has learned how to heat it in winter. He builds a furnace in which he can burn coal, gas, or oil from the earth. He has learned how to get these fuels from the inside of the earth by using tools that he has made. In the hot days of summer man keeps the buildings cool by using electric fans and other kinds of air-cooling machines.

Man uses machines to make warm clothes from the wool of sheep. He also grows cotton and flax and makes them into thread. He then weaves this thread into cloth.

Man grows all kinds of farm crops for food. He builds boats, trucks, trains, and even airplanes to use in shipping food to all parts of the world. He has found ways of keeping this food cool while it is being shipped. He has made cool places in which fruits, vegetables, eggs, and meat may be stored for months without spoiling.

If man wishes to live in places where there is not enough rain to grow crops, he brings in water from other places. He has learned to build dams to hold the water until he wants to use it. In places where there is too much water, man has made tools to dig ditches and drain off the water.

There are still places on the earth where man cannot live and be comfortable. He cannot live in the far north because it is too cold to raise food. He cannot live in the very dry parts of the desert because plants will not grow there. Even if food and other supplies were shipped into the desert, such a region would be an uncomfortable and expensive place for a home.

1. How does man protect himself and his property against insects, mice, and other harmful animals?

2. What does man do to keep himself warm that no other living things do?

Questions to Answer

1. How many ways can you name in which the following plants and animals are fitted to live where they do? squirrel, fish, polar bear, turtle, water-lily, cactus.

2. If you found a dead animal, how could you tell something about the kind of place in which it had lived?

3. Explain how this statement is true: "Insects are very well fitted to live where they do."

4. Tell how the structure of some animal helps it to do the following things: get air, find food, live on land, or live in water.

Things to Find Out

1. Find pictures of strange animals that show how they are fitted to live where they do.

2. Try to discover how different kinds of birds are especially fitted to:

(*a*) eat the kind of food they do.

(*b*) build their own kind of nest.

(*c*) escape from their enemies.

(*d*) live in the places they do.

3. Make a collection of pictures that show how the colors of some animals protect them.

4. Visit a zoo, if you can, and watch the animals to find out how they are especially fitted to (1) get food, (2) escape from their enemies, and (3) live where they do when they are in their natural homes.

5. Try to visit a greenhouse and look closely at different kinds of plants to see how they are fitted to (1) get food, (2) get water, (3) get air, (4) protect themselves.

6. Find out more about how birds migrate. Try to find the answers to these questions: Why do birds migrate? Where do they go? Do they fly at night or in the daytime? How fast do they fly?

7. Read about bird-banding and find out how the banding of birds helps scientists discover facts about bird migration.

SCIENCE WORDS

Can you say the word "characteristic"? Do you know what it means? You can tell by finding it in the following list of science words. This list shows you how to say, or *pronounce*, the science words in your book. It also helps you to know what these words mean.

The words are printed twice just as they are in a dictionary. The second time, there are marks over or under some of the letters to show how each letter should be pronounced. The part of the word which should be accented is marked ′. Some long words have both a main accent (′) and a lesser, or secondary, accent (′).

Study the following sounds, and they will help you understand what the marks mean:

a	at, can
ā	came, face
ä	far, father
ã	care, dare
ạ	alone, company
e	end, bend
ē	be, me
ė	her, longer
ẹ	towel, quiet
i	it, pin
ī	line, mine
o	rock, not
ō	broke, open
ö	moon, move
ô	off, song
ọ	connect, second
u	up, but
ū	use, pure
u̇	put, full
th	thin
ŦH	then

A single dot under ā, ē, ō, ö, or ū means that the sound is a little shorter and lighter, as in cottage (kot′ạ̄j), reduce (rẹ̄-dūs′), and into (in′tọ̈).

a cid (as′id), a sour material that turns blue litmus-paper red.

air-pres sure (ãr′presh′ėr), the force with which air presses against objects because of its weight.

aluminum (a-lū′mi-num), a very light-weight metal often used for making kettles, pans, and other kitchen-ware.

amphibian (am-fib′i-a̤n), an animal, such as the frog, that lives part of its life on land and part of its life in water.

aphid (af′id or ā′fid), a very small insect that lives on plants; a plant-louse.

bacteria (bak-tē′ri-a̤), very, very tiny plants.

barometer (ba̤-rom′e-tėr), an instrument for measuring the pressure of the air.

beetle (bē′tl), a kind of insect.

bulb, the thick underground stem which grows on some kinds of plants and produces a young plant.

canyon (kan′yo̤n), a narrow valley with high, steep sides, usually with a stream at the bottom.

carbon dioxide (kär′bo̤n dī-ok′sīd), a gas that cannot be seen or smelled and is made of carbon and oxygen.

cell (sel), the smallest part of a living thing. All animals and plants are made of small divisions called cells.

cereal (sēr′ē̤-a̤l), wheat or other grain used as a food.

characteristic (kar′a̤k-te̤-ris′tik), a special feature of a material that makes it different from other materials.

chemical change (kem′i-ka̤l chānj), a change in a material that makes a new or different material.

climate (klī′mā̤t), the kind of weather that a region has over a long period of time.

cocoon (ko̤-kön′), a silky covering made by some insects to live in while they are in an early form.

colony (kol′ō̤-ni), a group of animals or plants living together.

compound (kom′pound), a material made of two or more different elements joined together.

compressed (ko̤m-prest′), squeezed together into a smaller space.

con crete (kon′krēt or kon-krēt′), a material made of cement, sand or gravel, and water, which becomes hard as it dries.
con dense (ko̤n-dens′), change from a gas, or vapor, to a liquid or to a solid.
con ser va tion (kon-sėr-vā′sho̤n), saving. The conservation of trees is important.
con tract (ko̤n-trakt′), get smaller.
corn smut (kôrn smut), a plant-disease caused by a tiny fungus plant.
cra ter (krā′tėr), the opening at the top of a volcano.
cur rent (kur′e̤nt), a flow of air or water.
cut ting (kut′ing), a small shoot cut from a plant to grow a new plant.

de cay (dẹ̄-kā′), to rot.
dis solve (di-zolv′), change to a liquid form by mixing with a liquid. You can dissolve sugar in water.
drone (drōn), a male bee in the hive.
dune (dūn), a mound or ridge of loose sand heaped up by the wind.

el e ment (el′ẹ̄-me̤nt), the simplest kind of material. It cannot be separated into any other kind of material.
e rupt (ẹ̄-rupt′), force out suddenly, or explode. When a volcano erupts, it forces out lava and steam.
e vap o rate (ẹ̄-vap′ọ̄-rāt), change into a gas.
ex pand (eks-pand′), swell out or get larger.
ex per i ment (eks-per′i-ment), test to find out something.

Fah ren heit (fä′re̤n-hīt or far′e̤n-hīt), a kind of thermometer.
fer ti liz er (fėr′ti-lī-zėr), any material which is spread over the soil to make it richer in materials that plants need.
fixed pul ley (fikst pu̇l′i), a pulley that is fastened and does not move about.

fore cast (fōr′kast), tell what will probably happen. The weather bureau forecasts the weather every day.

ful crum (ful′krum), the point on which a lever turns in moving a weight.

fun gus (fung′gus), a kind of plant that has no green coloring material. Mushrooms are fungus plants.

gas, a material that is like air in form. Air is a mixture of different kinds of gases.

gla cier (glā′shiėr), a large mass of slowly moving ice.

Great Lakes (grāt lāks), Lakes Ontario, Erie, Huron, Michigan, and Superior.

ground-hog (ground′hog), a woodchuck.

gup py (gup′i), a very tiny fish that does not lay eggs but bears its young alive.

herd (hėrd), a number of animals together.

hi ber nate (hī′bėr-nāt), spend the winter in sleep as bears and some other wild animals do.

hy a cinth (hī′a̤-sinth), a spring flower that grows from a bulb.

in clined plane (in-klīnd′ plān), a simple machine made by inclining or slanting a board or other surface.

ir ri ga tion (ir-i-gā′sho̤n), supplying land with water.

lab o ra to ry (lab′ọ̄-ra̤-tọ̄-ri), a place where scientists work.

lar va (lär′va̤), an early form of an insect.

la va (lä′va̤), liquid rock that flows from a volcano.

le ver (lē′vėr or lev′ėr), a bar for raising or moving a weight at one end by pushing down at the other end.

li quid (lik′wid), a material that can be poured like water.

lit mus-pa per (lit′mus pā′pėr), a kind of paper used to test materials for acid.

mam mal (mam′a̤l), one of a group of animals. Mammals feed their babies milk from their own bodies.

mer cu ry (mėr′kụ̄-ri), a heavy, silver-colored metal that is a liquid at ordinary temperatures.

mi cro scope (mī′krọ̄-skōp), an instrument used to make very small things look larger, so that we can study them better.

mi grate (mī′grāt), move from one region to another. Many birds migrate to a warmer country in the fall.

min er al (min′e̤-ra̤l), a substance such as iron, that is found in the earth.

mis tle toe (mis′l-tō), a plant with small, waxy-white berries. It gets the water that it needs from trees.

mold (mōld), a hollow form into which melted materials are poured so that they will harden into shape.

mov a ble pul ley (mö′va̤-bl pu̇l′i), a pulley that moves with the weight; not a fixed pulley.

nec tar (nek′ta̤r), a sweet liquid found in many flowers.

non-liv ing (non-liv′ing), something that is not alive and never was alive.

ob ser va tion (ob-zėr-vā′sho̤n), things discovered by looking carefully.

ob serve (ọb-zėrv′), look carefully.

pack, a number of animals hunting together.

par af fin (par′a̤-fin), a white, tasteless material like wax, used for making candles and for sealing jars.

pen guin (pen′gwin or peng′gwin), a bird with flippers for diving and swimming.

pet al (pet′a̤l), one of the parts of a flower.

pis til (pis′til), the part of the flower that holds the seed.

pol len (pol′e̤n), a fine, yellowish powder on the stamen of a flower.

po ta to blight (pọ̄-tā′tō blīt), a plant-disease caused by a tiny fungus plant.

prai rie (prãr′i), a large piece of level land with grass but no trees.

pul ley block (pu̇l′i blok), several pulleys used together in a block.

pu pa (pū′pa̤), one of the forms in the life of an insect.

queen bee (kwēn bē), the mother bee in the hive.

ray (rā), a line or beam of light, as a ray of the sun.

ray on (rā′on), a kind of cloth that looks like silk.

reg is ter (rej′is-tėr), an opening through which heat can get into a room.

rep tile (rep′til or rep′tīl), a cold-blooded animal covered with scales, and having lungs for breathing.

root-hairs (röt-hãrz), tiny hair-like roots through which water comes into a plant.

sal a man der (sal′a̤-man-dėr), an animal belonging to the same group of animals (amphibians) as frogs and toads.

sap, the juice of a plant.

sci en tist (sī′e̤n-tist), a person who spends his life studying science and discovering things about the world.

se pal (sē′pa̤l or sep′a̤l), one of the leaf-like parts of a flower.

so cial (sō′sha̤l), living in a group.

sol der (sod′ėr), metal that can be melted and used for joining or mending.

sol id (sol′id), a material that is not a liquid or a gas. Iron, wood, and ice are solids.

spore (spōr), a single cell that can grow into a new plant. Ferns have spores.

sta men (stā′men), the part of a flower that contains pollen.

stig ma (stig′ma̤), a part of the pistil of a flower.

struc ture (struk′chėr), the parts of anything; the way in which the parts are put together.

tel e scope (tel′ẹ-skōp), an instrument which makes things that are far away look nearer.

transparent (trans-pãr′e̤nt), easily seen through.
transplant (trans-plant′), plant again in another place.

volcano (vol-kā′nō), a mountain having an opening through which steam, ashes, and lava may come out.

weather bureau (weŦH′ėr bū′rō), a department of the government that studies weather and makes daily weather maps.
wheat rust (hwēt rust), a plant-disease caused by tiny fungus plants.
worker bees, the bees that do the work in the hive.

INDEX

A star after a number (like 205*) means that there is a picture on that page.

Acid, test for, 204-205*, 223-224

Air, necessary to living things, 15, 16, 32, 33, 59, 200, 241, 245, 246-247, 248, 250, 251, 314, 315, 316; in beehive, 20; effect of heat on, 114-121, 115*, 117*; furnace using hot, 114, 116, 120*-121; effect of cooling on, 119*-120; water in, 128, 152-157; surrounds earth, 136-137; weather depends upon, 137*-142; wind is, 142-147, 152; -pressure, 143-145, 144*, 147, 148*-151, 149*, 152, 158, 160, 161-162; effect of on the earth's surface, 182*-184*; not an element, 212; carbon dioxide in, 250-251

Airplanes, and weather, 163, 164

Alcohol, 125, 126, 127

Alligator, 57, 291, 307*

Aluminum, 122, 213*

Amphibian, 287, 290*, 297, 309

Animals, 8, 12*, 14*, 24*, 27*, 40, 56*; helpful, 16-25, 29-34, 55-58; social, 17; food of, 18, 19*, 22-23, 28, 51-52, 57, 60, 233-240, 325; used as food, 24, 57, 60, 257; plants helpful to, 26-29; harmful, 44*-51, 45*, 46*, 47*, 48*, 49*, 50*; clothes from, 57, 330; work done by, 57; taking care of plants and, 59*-65, 61*; in soil, 194-195; structure of, 235*-240, 236*, 260-262; new animals from, 287-292; in different places, 301-305, 304*; land, 305-308, 306*, 307*, 309-310*; water, 315*, 317*-318*; effect of temperature on, 319, 321-324; protected from enemies, 326*-329, 327*, 328*

Ant-eater, 238*-239

Ants, 21*-23, 22*, 326*; -cows, 22*-23; and ant-eater, 238-239

Aphids, 22*-23

Apple, 41*, 48*, 52

Arctic Tern, 322

Ashes, 199, 210

Automobile, 69, 93, 94, 98, 125

Ax, 89*, 90, 91

Axle, wheel and, 91-96, 92*, 93*, 94*, 95*

Bacteria, 280*-281*

Baking-soda, 205, 214, 223-225, 228

Ball-bearing, 99-100

Bark, 14*, 15, 29, 44*

Barometer, 148*-151, 149*, 161, 164

Bats, 301, 324

Beak, of eagle, 236*; of hawk, 309

Bean, 255, 256, 257; pods, 274*

Bear, 65, 301, 324

Beavers, 25, 321, 328*, 329

Bed, of river, 178-179*

Bee, 8, 30*, 31, 310*, 326*; as social animal, 17*; kinds of, 18-20, 19*; carpenter, 323*
Beet, 52, 255, 256; sugar from, 249
Beetle, 236*, 296; pine trees killed by, 49*; boll weevil a, 49*-50
Belt, on wheel, 94*, 95-96
Bicycle, 69, 71, 94*, 98
Bill, of snipe, 237*; of woodpecker, 237; of hawk and owl, 326
Bird, 27*, 44*, 56*, 266*, 304*, 310*, 327; robin, 23; flock, 24; food for, 26, 31*-32, 57, 233, 295*; woodpecker, 27*, 28, 237; oriole, 28; nests, 28-29; carry seeds, 34; protection of, 65; hatch from eggs, 287-289, 288*; young, 295*; hawk, 304*, 308-309; migration of, 321-322*
Blight, potato, 41
Block and tackle, 78*-79*
Boats, and weather, 163, 164
Bobcat, 235*
Body, chemical change in, 210; made of elements and compounds, 219-220
Boiling-point, 125-126
Bollweevil, 49*-50
Bones, 220
Brain, 261-262
Branches, 246, 319
Brass, 123-124
Bread, mold, 41, 258*, 276-277*; chemical change in, 210-211
Bridge, effect of heat on, 105-106, 106-107*; painting, 219
Bronze, 124
Buds, on yeast plants, 280*; on potato plants, 283*, 284, 286; in winter, 319-320*
Buffalo, 60
Bulbs, 256*, 285*, 286
Burning, a chemical change, 209-210*, 223, 226
Burrs, 33-34*
Butterfly, 239*, 296, 310*; Monarch, 296, 322

Cabbage, 48*, 256
Cactus, 300*, 304, 305*, 311-312
Caddisworm, 328*
Calcium, 220
Camel, 57
Camp-fire, 63*
Can-opener, 69
Canyon, 168*, 178*
Carbon, 213, 215, 251
Carbon dioxide, 201, 214, 228; used by leaf, 250-251, 317
Carrots, 52, 242, 255, 256
Cat, 234, 235*, 239, 291, 294
Caterpillar, 46*, 47, 236*, 296*, 310*, 326*; tent, 50*
Cattle, 56*, 57, 88*, 89, 260*
Celery, 246, 255, 256
Cell, 29, 273*-275, 290, 291; dry, 212-213; of plant, 273*; division of, 274, 289*, 290, 292
Centipede, 310*
Changes, in weather, 133, 134*-142; in temperature, 136, 137, 138-142, 179-180; in air, 137; in air-pressure, 143-145, 147, 148*-151, 149*, 152; in earth's surface, 169-193*, 172*, 173*, 175*, 177*, 178*, 179*, 182*, 184*, 185*, 191*; in material, 199-200

CHARACTERISTICS, of materials, 202, 203*-204, 221; of glass, 202-203, 221-222*; changing, 206-211, 207*, 210*
CHEMICAL CHANGE, 198*, 209-211, 210*, 215, 218-219; using, 221-225, 222*, 224*; harmful, 225-230, 226*, 228*; in green plants, 242-251
CHERRIES, 274*
CHICKENS, 56*, 57, 239*; egg of, 288-289
CHIPMUNK, 323-324
CLAMS, 13, 326
CLAW, 310; of cat, 234; of dog, 234; of eagle, 236; of woodpecker, 237; of hawk, 309, 326
CLAY SOIL, 194
CLOTHES, from animals, 57; of man, 330
CLOUD, 141*, 153, 154*, 155, 157
COAL, 210, 330*
COLONY, of bees, 17*; of ants, 21, 22
COLORADO RIVER, 178*-179
COLORING, protective, 326-327
COMPOUNDS, 215, 216, 217, 218, 219*, 220, 221, 249
CONSERVATION, of plants and animals, 60-65, 61*, 62*, 64*
COOLING, effect of on solids, 105; effect of on air, 119*-120; effect of on gases, 128*-129; effect of on water in air, 153-157; effect of on rocks, 180*-181; stops chemical change, 229; buildings, 330; foods, 331
COPPER, 123, 124, 199, 212, 213*, 218
CORN, 41*, 260*, 274*; field destroyed by grasshoppers, 44*; as food, 51, 52, 255, 256, 260*; corn-starch from, 252; starch in, 253
COTTON, 53*; plant and boll weevil, 49*-50; characteristics of, 203; cloth, 330
COW, 26, 57, 239, 256, 291, 294; ant-, 22*-23; poisoned by some plants, 40
COW-BIRD, 295*
CRAB, 315*
CRATER, 191*
CRAYFISH, 317*-318
CREEK, 172, 175
CROCODILE, 291
CUTTINGS, 281-282*

DAHLIA, pollen grains of, 270*
DECAY, 194-195, 229
DEER, 14*-15, 26, 27*, 65, 329
DESERT, 331; plants of, 300*, 301, 311-313*
DEW, 156*
DOG, 239, 291, 294, 321; carries burrs, 33-34; work done by, 57; food caught by, 234
DOOR KNOB, 92*-93
DRAGON FLIES, 47
DUCK, 51, 65, 237
DUNES, 182*, 183
DUST-STORM, 182

EAGLES, 236-237
EARTH, 136; sun's rays heat, 139; clouds keep heat from, 141*; changes in surface of, 169-170, 173; appearance of, 170-174, 171*, 172*, 173*; effect of water on, 174-181, 175*, 176*, 177*, 178*, 179*, 180*: effect of air on, 182*-184*; effect of

Earth—Cont'd
plants on, 185*; effect of glaciers on, 186-188; effect of volcanoes on, 189-191*, 190*; mountains made on, 192-193*
Earthworm, 32*-33
Egg, of queen bee, 20; of queen ant, 22; of aphids, 23; of birds, 28, 65, 287-289, 288*, 295; of insects, 46*-47, 48, 289, 296, 322; of flies, 48; of plant, 272, 273, 274, 287; of spiders, 288*; of amphibians, 290*, 297; of fish, 290, 297; of sandpiper, 327*
Egg-beater, a machine, 69, 92*, 95
Elements, 200; kinds of, 211-214, 213*; put together, 214-220, 217*, 219*, 221; in sugar, 215, 249; in compounds, 215, 216, 217, 218, 219*; in salt, 218
Elephant, 26, 234, 294
Engine, gasoline, 71; and friction, 97
Eskimo, home of, 140*
Evaporation, of liquids, 126-128
Experiments, what they are, 9*-10
Eyes, of cat family, 234, 235*; of potatoes, 283*-284

Farm, 40, 41, 59*, 60
Fat, in plants, 254
Feet, of cat family, 234, 235*; of ducks, 237; of land animals, 309-310
Ferns, 36-37, 276, 279
Fertilizer, 59-60
Film, chemical change in, 224*
Fingers, 261
Fire, forest, 38-39, 61*-63*, 62*; camp-, 63*; early ideas about, 200; as a chemical change, 209-210*, 226*-228*; not an element, 212
Fire-extinguisher, 228*
Fish, 13, 56*, 192*, 236*, 287, 290-291, 297*, 301, 303, 304*, 317, 318, 327; starfish, 315*
Flax, 53*, 330
Flies, 296, 306; ruin fruit and vegetables, 48
Floods, 53-54
Flowers, 8, 320; helped by bees, 30*-31; weeds enemies of, 43; picking wild, 63-64; seeds made by, 267-271*, 268*, 269*, 270*, 286; plants without, 276
Fog, 137*, 152, 153, 157
Food, 253*; made by plants, 8, 241*-257, 315, 319; of living things, 16, 59, 233-262, 325; of animals, 18, 19*, 22-23, 28, 51, 57, 234-240, 308, 309, 315, 325-326; of plants that are not green, 35-36, 257-259; in soil, 39, 194; of man, 60, 211, 220, 260*-262, 331; shipping, 164; of mammals, 235, 292, 294; stored by plants, 255-257, 256*, 283, 284, 285*; of insects, 296
Force, necessary to machine, 70; and machines, 71*; and pulleys, 78, 79, 80; and levers, 82, 84-86, 85*; and inclined planes, 88; and wheel and axle, 93, 99; and friction, 97; of water, 177*-178*, 179*-180*, 189; of wind, 182*-184*, 189; inside earth, 189, 192-193*

Forest, destroyed by deer, 14-15; effect of fire on, 38-39, 61*-63*, 62*; protection of, 60-62*, 61*; spraying, 64*; home of birds, 65; living things in, 302*
Forest fire, 38-39, 61*-63*, 62*
Fox, 26-28, 321
Friction, 96-100
Frog, 265, 266, 290, 297, 307, 308, 309*, 324, 327
Frost, 156, 157
Fruit, 50, 51, 52; pollen necessary to grow, 31; mold on, 41*; ruined by flies, 48; spraying, 60; effect of frost on, 164
Fuels, used by man, 330
Fulcrum, 82, 83, 84*, 85*, 86
Fungus, 35*-36, 41, 258*-259
Furnace, 330; hot-water, 112*-113; hot-air, 114, 116, 120*-121

Gas, effect of heat on, 114-121; effect of cooling on, 120-121; heat changes liquids to, 125-129, 127*; in volcanoes, 189-190; as a material, 201; as elements, 212; in furnace, 330
Gasoline, engine, 71; evaporation of, 126
Gear-wheel, 95*
Geese, 64, 65
Geranium, 281, 282
Gills, 318
Glaciers, 186-188*, 187*
Glass, sun's rays pass through, 139; characteristics of, 202-203; -making, 221-222*
Glue, 57
Gold, melting-point of, 123; as an element, 212, 214
Goldenrod, eaten by insect, 46*
Goldfinch, 327
Gorilla, 261
Grain, 255; of sand, 183*; of pollen, 270*-271, 272-275
Grand Canyon, 178*-179
Grass, as food, 26, 51; in nests, 28; needs sunshine and water, 43; quack, 284*
Grasshoppers, 29, 290, 296, 306*; harm to corn-field by, 44*
Great Lakes, 141, 187
Green coloring, in plants, 247, 251
Groundhog, 324
Gulf of Mexico, 176-177
Guppies, 291

Hail, 152, 153, 155; -stones, 156*
Hair-cap moss, 278*
Hammer, 69; claw-, 70, 86*
Hands, 260, 261-262
Hawk, 236*, 304*, 308-309, 326
Heat, effect of on solids, 103-108, 104*, 106*, 107*, 122*-124*; effect of on liquids, 108-113, 109*, 111*, 112*, 125-129, 127*; effect of on gases, 114-121; from sun, 139, 140, 141, 142; effect of on rocks, 180*-181; in volcanoes, 189-190; effect of on sugar, 207*-208; effect of on iron and sulphur, 217*; used in making glass, 221-222*; in buildings, 330
Heath-hen, 64
Hemp, 53*
Hibernation, 323-324

HILLS, sand, 182*, 183; effect of glacier on, 186, 187
HIPPOPOTAMUS, 291*
HOMES, of man, 140, 329, 331; chemical changes used in, 223; of animals, 328*
HONEY, made by bees, 18, 19*
HORSE, 26, 239, 294; poisoned by some plants, 40; harmed by insects, 47; work done by, 57
HUMMING-BIRD, 239, 322
HYDROGEN, 215

ICE, 122*-123, 152*, 186, 187*-188*
INCLINED PLANE, 87*-91*, 88*, 92; wedge, ax, and plow as, 89*; screw as, 90*
INDIAN, 91, 123, 133; rain dance of, 132*
INSECTS, 29, 302, 309, 327, 328; bees, 8, 17*-20, 19*, 30*, 31, 310*, 323*, 326*; social, 21; ants, 21*-23, 22*; as food, 23, 31-32, 42*, 57, 233; grasshopper, 29, 44*, 290, 296, 306*; enemy of plants, 31, 44-51, 46*, 47*, 48*, 49*, 50*; larvae of, 46, 48*-49, 289; spraying of, 60, 64*; in soil, 194; butterfly, 239*, 296*, 310*, 322; as group, 287; young, 296*; in winter, 322-323*
IODINE, used in testing for starch, 252-253*
IRON, effect of heat on, 106, 122; melting of, 123, 125*; rust on, 208, 218, 219; as an element, 212, 213, 214; and sulphur, 216*-217*; in buildings, 329-330
IVY, 281-282*

JACK-IN-THE-PULPIT, 36*

KANGAROO, 294*

LAKE, 171, 187, 188
LAKE SUPERIOR, 187
LARVAE, of insect, 46, 48*-49, 289, 296*
LASSEN PEAK, 191
LAVA, 190*, 191
LEAD, 122*, 206, 219; melting-point of, 123; as an element, 212, 213*, 214
LEAVES, used in birds'-nests, 28-29; poison-ivy, 40*; catch insects, 42*; as food, 44, 48*, 49, 256; chemical change in, 209, 210*; make food, 241*, 242, 245*, 246-247*, 248-257, 252*, 315; new plants from, 282-283, 287; of desert plants, 312-313*; air needed by, 314; of water plants, 315, 316, 317; effect of weather on, 319; buds of, 320*
LEGS, 310; of frog, 309; of cray-fish, 317*; of water-bug, 318*
LEMON, 205
LEMON-SQUEEZER, 86
LEOPARD, 12*; Mexican, 304*
LEVER, 81-86*, 82*, 83*, 84*, 85*, 92; see-saw as a, 82*, 84*; tack-puller as a, 84*-85; nutcracker as a, 85*; other machines as, 85-86*; and friction, 97
LIFE-BOAT, pulley blocks used on, 80*
LIGHT, needed by living things, 16; needed by plants, 250

Lightning, 134*; a cause of forest fires, 62
Linen, 53
Lion, 26-28, 264*
Liquids, effect of heat on, 108-113, 109*, 111*, 112*, 125-129, 127*; solids changed to, 122-124*; as materials, 201
Litmus-paper, 204, 205, 223
Living things, help each other, 13-39; things needed by, 15-16, 325; plants and other, 39-43; animals harmful to, 44-51; food of, 233-262; as food, 260*; young of, 266, 287-292, 290*, 291*, 293*-297*, 294*, 295*, 296*; structure of, 272-273*; live in different places, 301-318; change, 319-324; protection of, 325-329
Lizard, 291, 302, 307*
Loam, 194
Locomotive, steam, 69, 71; part of, 80*
Lungs, 306
Lynx, 235*

Machine, as a helper, 69-71*, 70*, 86*, 329; simple, 71, 72, 81, 87; pulley as, 72-81, 73*, 74*, 75*, 76*, 77*, 78*, 79*, 80*; lever as, 81-86*, 82*, 83*, 84*, 85*; inclined plane as a, 87*-91*, 88*, 89*, 90*; wheel and axle as a, 91-96, 92*, 93*, 94*, 95*; and friction, 96-100, 98*, 99*
Magnet, 216*-217*
Mammal, 235, 287, 291*-292, 306
Man, food of, 260*-262, 329, 331; buildings of, 329-331
Marsh-mallow, pollen grains, 270*
Material, sun heats, 139-140; changes in, 199-200, 206*-211, 207*, 208*, 210*; kinds of, 201; characteristics of, 202-204, 203*; test for acid in, 204-205*; dissolving, 206-207; and elements, 211-214, 213*, 215, 216, 219*; new, 221-223, 222*
Medicine, from plants, 53*
Melting-point, of solids, 122-123
Mercury, boiling-point of, 125; used in barometer, 148-151; as an element, 212
Metal, effect of heat on, 106-107; mixing, 123-124*
Microscope, 265, 272, 279; snowflakes under, 155*; grains of sand under 183*; bread mold under, 258*; pollen under, 269-270*; plant cells under, 273*
Migration, of birds, 321-322*; of insects, 322
Milk, 220; chemical change in, 223-225, 229
Minerals, needed by plants, 244-245, 248, 250, 251
Mississippi River, 176*
Mistletoe, 36*, 40-41
Mixture, 216*-217
Mold, 41, 276-278; bread, 258*, 276-277*
Mole, 304*, 308
Monkey, 261, 310
Moths, 29, 327*
Mountain, 141*, 169, 172*-173*, 177, 189, 192-193*
Mountain-lion, 235*, 264*; saves forests, 14-15

Mt. Shasta, 191
Mushrooms, 259, 276, 278, 301
Musk-oxen, 24*
Muskrat, 293*, 321, 328, 329
Mussels, 315*

Nectar, used by bees, 18, 30, 31
Newt, 315*
North America, glacier on, 186-187*
Nickel, 212, 213*
Nitrogen, 212
Nutcracker, 85*

Ocean, 170-171*, 176; effect of on temperature, 141; plants and animals in, 302
Oil, used in machines, 97-98*, 100; in plants, 254; in furnace, 330
Opossum, 293*, 294, 310, 327*, 328
Oranges, 52
Orange-squeezer, 69, 70
Oriole, 28; Baltimore, 322
Owl, 236, 326, 327*
Oxen, work done by, 57
Oxygen, as an element, 212, 215, 219; causes rust, 218, 225-226; and copper, 218; needed for burning, 227-228

Paint, 52, 219; used to stop rust, 226
Palm tree, 304, 305*
Pangolin, 326*
Paper, making, 222-223
Paraffin, 122*
Passenger-pigeons, 64
Pencil-sharpener, 69, 92*, 93
Penguin, 294*, 301
Petal, 268*, 269*
Pheasant, 65
Phosphorus, 220
Pig, 51, 57, 294
Pine tree, harmed by beetle, 49*; paint from, 52
Pistil, 268-269*, 270*, 271
Pitcher-plant, 42*
Plants, food of, 8, 43, 49, 233, 241*-259, 245*, 249*; and animals, 15, 26-29, 29-34*, 30*, 31*, 32*, 44*; as food, 26-28, 51-52*, 267*, 325; insects enemies of, 31, 44*-51, 46*, 48*, 49*, 50*, 57; helpful to other plants, 35*-39, 36*, 37*, 38*; fungus, 35*-36, 41*, 257-259, 258*; harmful, 39-43, 40*, 41*, 42*; and people, 51-55, 52*, 53*; medicine from, 53; prevent floods, 53-54*, 55; taking care of animals and, 59*-65; new plants from, 64, 267-275, 276-286, 277*, 278*, 281*, 282*, 283*, 284*, 285*, 287; earth's surface changed by, 185*, 190; in soil, 194-195; that are not green, 257-259, 258*; cells of, 273*; live in different places, 300*, 301-305*, 302*; land, 311*-314, 313*; water, 315*-317, 316*; and change of temperature, 319-321; protection of, 325*-326
Plaster, 57-58
Plow, 69, 89*, 90
Plum, 41*
Poison, used in spraying plants, 60
Poison-ivy, 39-40*
Poles, animals living at, 301

Pollen, gathered by bees, 18, 30*-31; use of in flowers, 269-271*, 270*, 272, 274, 287; tube, 271*, 272
Pond, 302*
Porcupine, 44*, 326
Post-puller, 86*
Potatoes, 52; blight, 41; starch in, 253; sweet, 255; growing new plants from, 283*-284, 286
Praying mantis, 47*
Puffballs, 36, 251, 259, 276
Pulley, 72-81; fixed, 73*-76*, 74*, 75*, 79*, 80; movable, 76-78*, 77*, 79*, 80; block, 78*-80*; block and tackle, 78*-79*
Pump, 86*
Pumpkin, 267*
Pupa, 289

Quack grass, 284*

Rabbits, 237, 291, 329; young, 24, 28, 294; eat plants, 44; caught, 235-236
Raccoon, 310*, 321, 329
Rain, 8, 54, 55, 133, 134*, 152-153, 154-155, 159, 165, 174, 176, 185, 190, 330, 331
Rayon, 225
Rays, heat from sun's, 139
Reptiles, 287, 291, 297, 306
River, 53-54, 171*, 172, 173-174, 175*, 176*, 178, 179*
Robin, 240; feeding nest of young, 23
Rock, melting, 123; part of earth, 136, 192; heated by sun, 139; effect of water on, 177*, 180*; effect of heat and cold on, 180*-181; effect of wind on, 183-184*; effect of plants on, 185*; and glacier, 186-187; from volcanoes, 189-191*; in clay soil, 194
Rocky Mountains, 192, 193
Roller-skates, 98*
Root, 32, 43, 54, 59, 185*, 194, 242-244, 248, 319, 321; -hairs, 243*, 244, 248; food stored in, 255, 256*, 285*; and new plants, 282, 283*, 284*-285, 286, 287; of desert plants, 313; of water plants, 315, 316, 317
Rope, 53
Rose, 268*, 271
Rubber, 52, 203
Runners, 283*
Rust, 208*-209, 218, 219, 225-226, 229; wheat, 41; apple, 41

Salamander, 297, 307, 308*, 315; eggs of, 290*
Salt, 207, 214, 218-219
Sand, 182, 183, 184; hills, 182*; grains of, 183*; in soil, 194; used in glass, 221-222*
Sap, 255; insects take, 49
Sawmill, 88*
Scientists, what they are, 10
Scissors, 69, 70
Scooter, 99*
Screw, 90*, 91*
Sea, 171, 176
Seasons, 8; living things change with, 319-324
Seeds, made by flowers, 8, 64, 267, 270-271, 272, 275, 274*, 287, 320-321; as food, 26, 255-256; pollen needed by, 30; carriers of, 33-34*; earth's surface changed by, 185;

SEEDS—Cont'd
sprouting, 243-244; plants without, 276, 278, 279
SEESAW, as a lever, 82*, 84*
SEPAL, 268*, 269
SHADE, needed by some plants, 36-37; not needed by grass, 43
SHARKS, 291
SHEEP, 26, 51, 56*, 59*; poisoned by some plants, 40; as food, 57; furnish clothing, 57, 330
SHRUBS, 246, 319-320
SILVER, 212, 213*
SKIN, of land animals, 307-308; covering of plants like, 311-312
SKUNK, 321
SKUNK-CABBAGE, 325*
SLEET, 152, 153, 155
SMOKE, carried by air, 116-117*
SMUDGE POTS, 165*
SMUT, corn, 41*
SNAILS, 29, 326*
SNAKE, 57, 238*, 291, 324, 328
SNIPE, 237*
SNOW, 54, 55, 133, 134*, 152*, 153, 155, 159, 163*, 174; -flakes, 155*
SOCIAL ANIMALS, 17; bees, 17*-20, 19*; ants, 21*-23, 22*
SOIL, eaten by earthworm, 32*-33; top-, 39; and plants, 54*, 55, 185, 200, 242, 313; part of earth, 136, 192; heated by sun, 139; carried away, 170; in streams, 175, 177-178; carried by wind, 182-183; carried by glacier, 187; from volcanoes, 189, 190; materials in, 193-195; kinds of, 194; not an element, 212
SOLIDS, effect of heat on, 103-108, 104*, 107*; melting-point of, 122-123; as materials, 201
SPARROW, 235-236, 237
SPIDERS, 29, 45*, 310*
SPORES, 276-278*, 277*
SQUIRREL, 26, 236*, 237, 291, 310, 321
STAMEN, 269*, 270*
STARCH, 253; sugar changed to, 252, 254
STARFISH, 315*
STEAM, 128*, 155; locomotive, 69, 71; in volcanoes, 189
STEEL, effect of heat on, 107; rust on, 208, 209; in buildings, 330
STEM, 242, 245, 246, 248, 320; food stored in, 255, 256; new plants from, 282, 283*, 286, 287; of desert plants, 312, 313; of water plants, 315, 316, 317
STICKLEBACK, 297*
STIGMA, 270*, 271
STORMS, dust-, 182
STRAWBERRY, 283*
STREAM, 171*, 175*-176, 177
STRUCTURE, of animals, 235*-240, 236*, 237*, 239*, 303-305, 304*, 306, 308, 310*, 315*, 317-318; of snake, 238*; of butterfly, 239*; of plants, 241, 303-305*, 311-314, 313*, 315-318; of leaf, 246-247*, 314; of man, 260-262; of flowers, 267-271*, 268*, 269*, 270*
SUGAR, dissolving, 206-207, 209; heating, 207*-208, 209, 214-215; elements in, 214, 215, 249; made by green plants, 248-249*, 251, 252, 254

SULPHUR, as an element, 212; iron and, 216*-217*
SUN, 8, 134*, 190; some plants shaded from, 36-37; and vines, 37*; needed by green plants, 250, 252; and clothes, 127*; heats air, 139-140, 141, 142
SUNLIGHT, needed by green plants, 43, 250, 251; cause of chemical change, 229-230

TACK-PULLER, 84*-85
TADPOLE, 289*, 290, 297
TAIL, of hawk, 308; of frog, 309; of fish, 317; of squirrel, 321
TEETH, on gear-wheel; 95*, of cat family, 235*; of snake, 238*; of man, 260
TEMPERATURE, 108, 122, 125; and weather, 135, 138-142, 155, 158, 159, 161; changes in, 136, 152; effect of changes on living things, 319-324
THERMOMETER, 108, 110, 116, 122-123, 125, 126, 148, 164
THISTLE, 325*
THORN, 40, 325*
TIGER, 26, 28, 326
TIN, 124
TOAD, 237, 265, 290, 297, 327*
TOADSTOOLS, 251, 259, 276
TONGS, 85-86*
TONGUE, of woodpecker, 237; of toad, 237; of ant-eater, 238*-239
TOOLS, of man, 329, 330
TREE, 14*-15, 43, 44*, 279; and squirrels, 26; and mistletoe, 36*, 41; and other plants, 38*-39; and insects, 47, 48, 49*, 50*; rubber, 52; paint from pine, 52; spraying of, 60; protection of, 60-62*, 61*, 64*; and forest fires, 61*-63*, 62*; ice on, 152*; in rock, 185*; paper from, 222-223; food stored by, 256; in winter, 319-320; man uses, 329
TUNGSTEN, 213
TURTLES, 291, 324, 326, 327
TWIGS, 14*; in birds' nests, 29

VALLEY, 173, 188
VEGETABLES, 51, 52, 279; weeds enemies of, 43; eaten by larvae, 48
VEINS, of leaf, 247*, 248, 250
VENUS FLY-TRAP, 42*
VINE, needs sun, 37*
VINEGAR, 204, 228
VOLCANOES, 123, 189-191*, 190*, 192

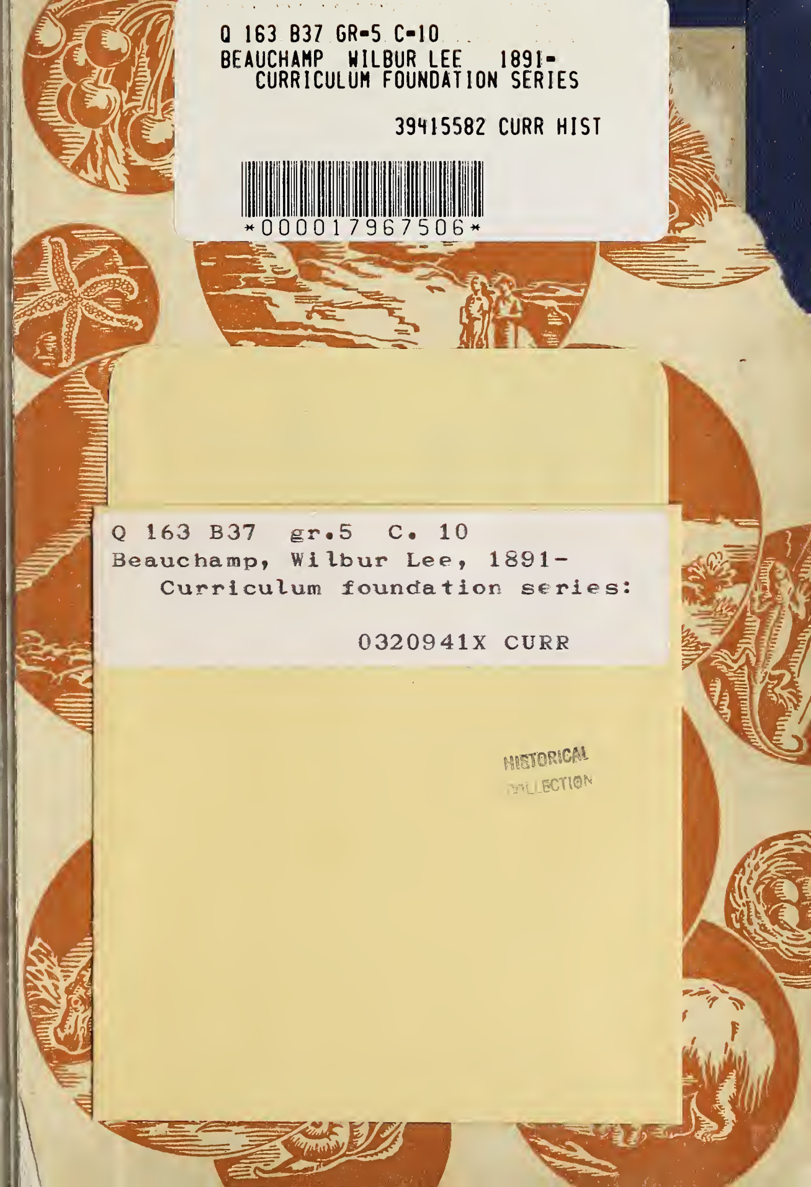
WASP, 19, 296
WATCHES, 71; and friction, 97
WATER, 8, 54; necessary to living things, 15, 33, 59, 200; and plants, 32, 33, 43, 59, 242-244, 245*-248, 250, 251, 317; and mistletoe, 36*, 40-41; effect of heat on, 108-110, 109*, 111*, furnace using hot, 112*-113; changes to ice, 123, 152*, 179; boiling-point, 125; evaporation of, 126-127*, 311-312; in air, 128, 153-157; from water vapor, 128*-129, 154-155; part of earth, 136, 169, 170-171*, 172, 173; heated by sun, 139, 140; effect of on temperature, 141-142; has weight, 143; effect of on earth, 174-181, 175*, 176*,

WATER—Cont'd
 177*, 178*, 179*, 180*; from glacier, 187*; changes in, 206; and elements, 212, 214, 215; and fire, 226*, 228; animals drink, 239*; minerals in, 244, 248, 251; plants and animals in, 301, 302-303, 315*-318*, 316*, 317*; in desert plants, 312, 313; used by man, 331
WATER-BUG, 318*
WATER-HYACINTH, 316*
WATER-LILY, 304, 305*, 316
WAX, 206*
WEASEL, 44*, 327
WEATHER, 8; changes in, 133, 134*-139, 137*, 140, 141, 152*, 156; forecasting, 158*-165, 163*; map, 159, 160*, 161; stations, 159-160; effect of on plants and animals, 319-324
WEATHER BUREAU, 158*, 159, 160, 161, 163-164, 165
WEDGE, 89*, 91
WEEDS, 60; enemies of flowers and vegetables, 43, 284
WEIGHT, and pulleys, 72, 73*, 76*-77*, 78*, 79*; and levers, 33*-44*; and inclined planes, 87*, 88*, 89, 90, 91*; of air, 118, 143, 152
WHEAT, as food, 51, 255
WHEEL, 72; and axle, 91-96, 92*, 93*; belt on, 94*, 95-96; gear-, 95*; and friction, 97, 99*
WHITE, of egg, 288
WIND, 8, 133, 134, 135, 138, 140-141, 159, 190; a cause of fire, 63; made to blow, 142-147; air-pressure as cause of, 147, 152; effect of on earth's surface, 182*-184*; blows pollen grains, 270-271
WINGS, 308, 309
WOOD, 199, 209, 222, 223, 225
WOODCHUCK, 236*
WOODPECKER, 27*, 28, 237
WORK, machines help in, 69-71
WORLD, 7; cold and hot parts of, 140
WORMS, as food for birds, 23; cut-, 29, 49; cabbage, 48; corn-, 49; silk-, 57; caddis, 328*
WRENCH, 70*

YEAST PLANT, 279-280*, 281
YELLOW WARBLER, 295*
YOLK, of egg, 288-289
YUCCA, 313*

ZINC, 123, 213*, 219

SCHOOL DIVISION
PUBLIC LIBRARY
WETASKIWIN, - ALBERTA.



Q 163 B37 GR-5 C-10
BEAUCHAMP WILBUR LEE 1891-
CURRICULUM FOUNDATION SERIES

39415582 CURR HIST

000017967506

Q 163 B37 gr.5 C. 10
Beauchamp, Wilbur Lee, 1891-
Curriculum foundation series:

0320941X CURR

HISTORICAL
COLLECTION